A-621.052 627
627

Water Power

INTERNATIONAL DEVELOPMENT OF HYDRO-ELECTRIC POWER

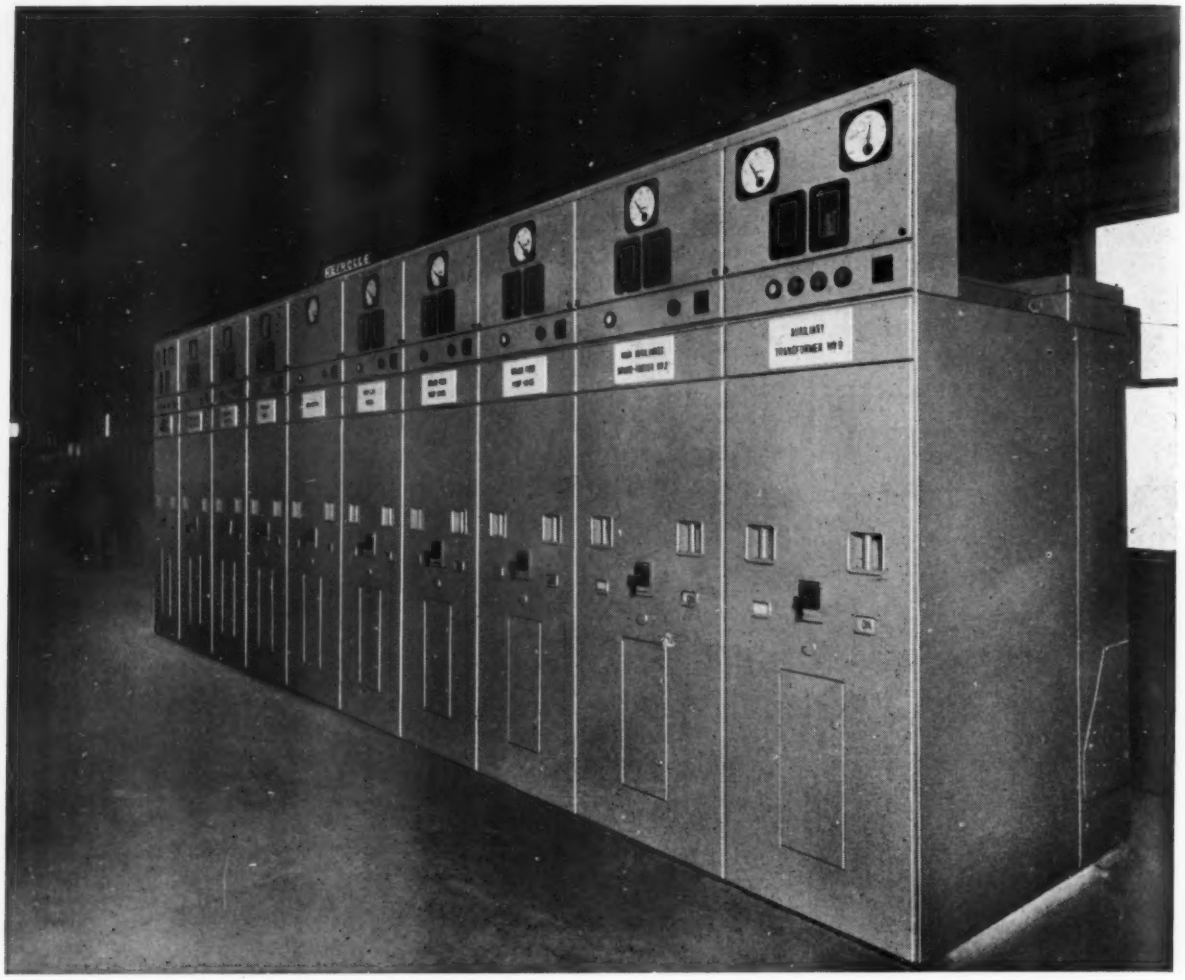
PRICE 2/6 JULY 1952

THE JOHN CRERAR LIBRARY
RECEIVED
JUN 8 1953
THE JOHN CRERAR LIBRARY
JUL 1 1952
LIBRARY

HYDRO-ELECTRIC
POWER IN INDIA

The Madras Government Irrigation and Power scheme depends on hydro-electric stations such as Mettur Dam shown. Metrovick generators, transformers, switchgear and protective apparatus, etc. are used extensively on the system. Mettur station contains 4 Metrovick 12,500 kVA generators.

METROPOLITAN-VICKERS ELECTRICAL CO. LTD
MANCHESTER 17, ENGLAND
Member of the A.E.I. group of companies



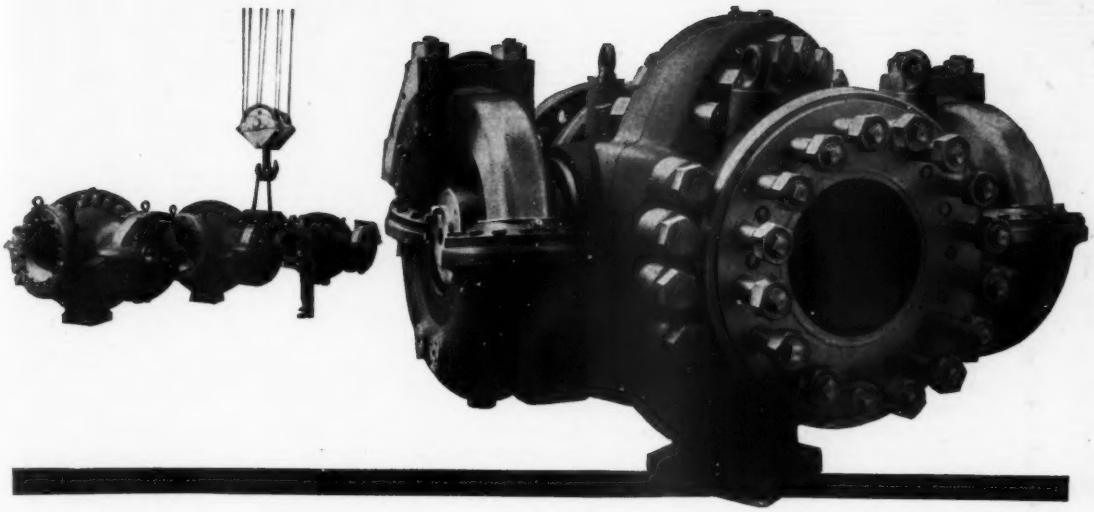
AIR-BREAK SWITCHGEAR AT CLYDESMILL

At Clydesmill Power Station, Reyrolle 150 MVA 3·3 kV air-break switchgear has been installed for controlling the power station auxiliaries. The panels are of air-insulated metal-enclosed construction with 150 MVA magnet-operated circuit-breakers. The circuit-breakers are isolated for maintenance and inspection on integral carriages and as they have easily removable arc-chutes, the whole contact assembly is readily examined. Particular care has been taken in designing the exterior and the result has been panels of neat and clean appearance.

If you want to talk switchgear ... talk to Reyrolle

A. Reyrolle & Company Ltd., Hebburn, Co. Durham.

CRC 18S



Rotary Slide Valve
with hydraulic rotary-piston drive
and dual sealing. Diameter of bore 600 mm.
Working pressure 150 atm.,
Testing pressure 270 atm.,
Face-to-face length 2600 mm.
Height 2100 mm., width 3000 mm.

Equipment for Hydro-Electric Power Stations

Complete barrage installations; hoisting equipment and cranes; sluices and sluice-valves; grid clearing machines; shut-off valves for high-pressure conduits; high-pressure conduit fittings; circular slide valves; rotary slide valves with hydraulic rotary-piston drive; shut-off valves for emergency and bottom outlets; piping systems for oil and cooling-water plant; funiculars and aerial cableways for passenger and goods transport; building machinery for dam-building work.

DE ROLL

Louis de Roll Iron Works Ltd., Works at Gerlafingen (Head Office),
Klus, Olten, Rondez, Choindez, Berne (Switzerland)

889

FOR DEPENDABLE PERFORMANCE

Specify

BUTTERS DERRICKS

Vast numbers of structural and engineering developments have come to fruition under the jibs of Butters Cranes—operations where the constant flow of materials is vital and where the absolute reliability of the gear is essential.

One of the many, the Ballyshannon Hydro-Electric Scheme (Main Civil Engineering Contractors: Messrs. Cementation Co. Ltd., Doncaster) is illustrated, showing two of several Butters Derricks which were employed.

We will be pleased to submit details of our standard range or to quote against requirements.

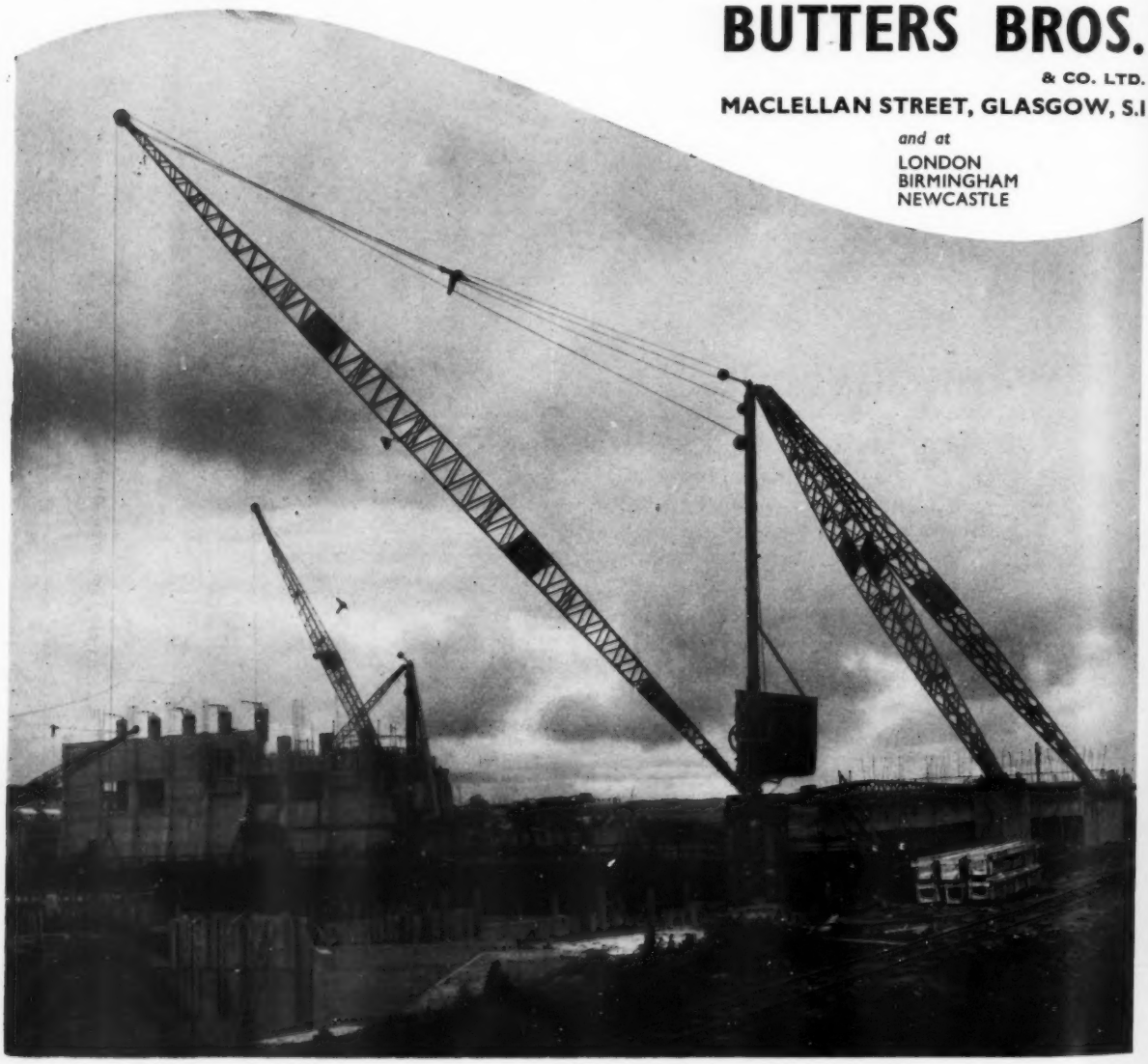
BUTTERS BROS.

& CO. LTD.

MACLELLAN STREET, GLASGOW, S.I

and at

LONDON
BIRMINGHAM
NEWCASTLE



An impression of the Pangani Falls.

* * *

TANGANYIKA
The Pangani Scheme

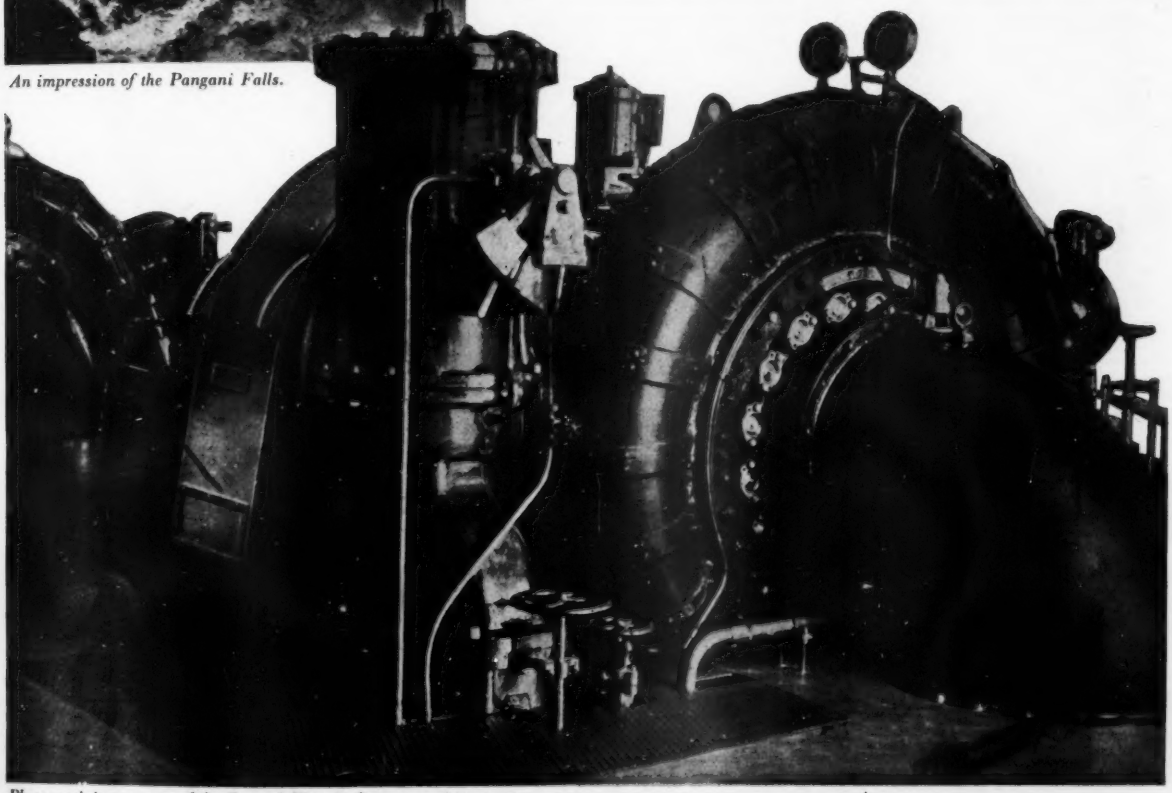
The lower photograph shows two of the machines built by us. Three 3600 BHP and one 7200 BHP turbines are in service and a further 7200 BHP unit will shortly be installed. All are horizontal shaft Francis turbines, the larger sets being of the twin runner type. The whole of the design and construction of Pangani Scheme was executed by Messrs. Balfour, Beatty & Co. Ltd.

Boving & Company Ltd.

WATER POWER ENGINEERS

Head Office:
56, KINGSWAY, LONDON, W.C.2,

Branch Offices: Wellington, Druids Chambers, Woodward Street.
Melbourne: 99 Queen Street.
Calcutta: c/o Messrs. Macneill & Barry Ltd., 2 Fairlie Place.
Chittagong: (Pakistan) c/o Messrs. Macneill & Barry Ltd., Strand Road.



Photograph by courtesy of the General Electric Company of England.

The fastest, most economical method of placing BULK CONCRETE giving

Blaw Knox concrete pipe lines on the construction of the Royal Festival Hall—Main Contractors—Messrs. Holland & Hannen and Cubitts Ltd.

BETTER
placing of high quality concrete at the lowest cost per cubic yard.

BETTER
placing on awkward sites—uphill, downhill and underwater . . . traversing highways and railway tunnels without obstructing traffic.

BETTER
placing without rehandling problems . . . no chutes, hoists, towers, buckets, cranes, etc.

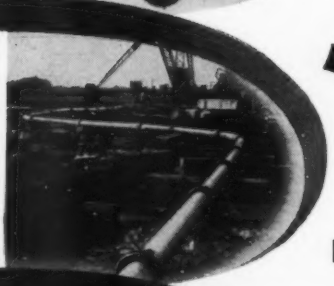
BETTER
utilisation of man-power—with one man more concrete can be placed than by a whole team using old fashioned methods.

PUMP IT

Basic component of the system is the BLAW KNOX portable, two speed, heavy duty, single acting horizontal piston pump. Capacity 15-20 cubic yards of concrete per hour.

PIPE IT

BLAW KNOX Concrete Pipelines comprise 6" steel pipes in various lengths up to 10' and simple, quick-acting couplings with rubber seatings for fast assembly and dismantling. During pumping the pipeline is completely filled, concrete moving through in synchronous impulses in an excellent state of uniformity.



PLACE IT

Concrete is poured straight into the forms, exactly where it is needed.

Blaw Knox engineers will be glad to advise on the application of the Concrete Pump to specific jobs.

BLAW KNOX

BK.63

BLAW KNOX *Concrete by Pipeline*

BLAW KNOX LIMITED, 90/94 BROMPTON ROAD, LONDON, S.W.3
Telephone: Kensington 5151 Telegrams: Blawnox, Southkens, London

HIGH TENSION SALVI IFI MILANO LINE FITTINGS

For 30 years Messrs. A. Salvi & Company, Milano, Italy, have specialised in the design and manufacture of complete equipment for Overhead Transmission Lines, including Compression Dead Ends, Assemblies and Joints. Suspension and Strain Clamps. Arcing Horns. Guard Rings. Shackles. Armour Rods. Galvanized Bolts and Nuts, etc.

The Works of the Salvi Company are engaged exclusively in the production of high grade Fittings for High Tension and Extra High Tension Transmission Systems, up to and including pressures of 220/380 KV, and for all sizes of Copper, A.C.S.R. and Aluminium Alloy Conductors.

We shall be glad to receive enquiries and to provide a data sheet indicating the details we require to enable us to quote for your requirements.

SOLE REPRESENTATIVES IN THE UNITED KINGDOM AND THROUGHOUT ALL DOMINION COUNTRIES AND BRITISH COLONIES AND PROTECTORATES

FERRUM (ENGLAND) LIMITED • **ENGINEERS** **STAFFORD HOUSE • 43 NORFOLK ST. • LONDON, W.C.2**

The safe link

We specialise in manufacturing Power Transformers for Generation. Transmission and Distribution. All YORKSHIRE Transformers are designed, constructed and tested to the corresponding British Standard Specification.

We make Transformers to suit all requirements up to 45,000 k.V.A. - 132,000 volts.

YORKSHIRE TRANSFORMER

YET

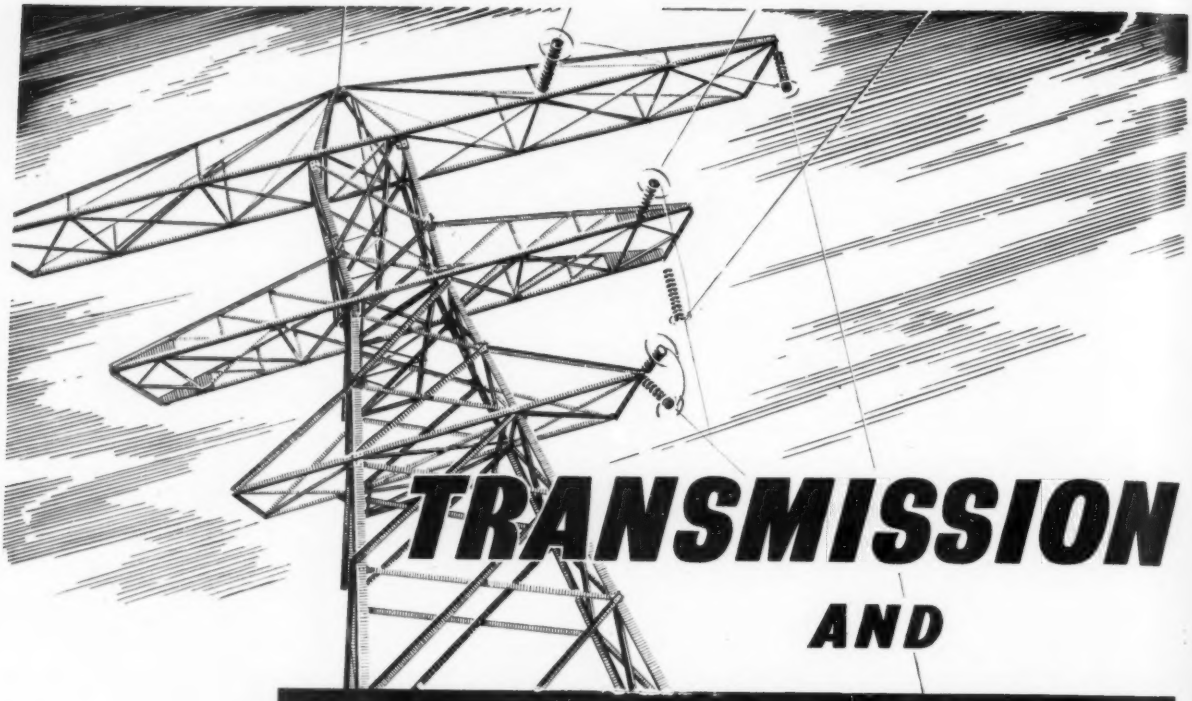
Phone. DEWSBURY 1691/2

YORKSHIRE ELECTRIC TRANSFORMER Co LTD DEWSBURY · ENGLAND

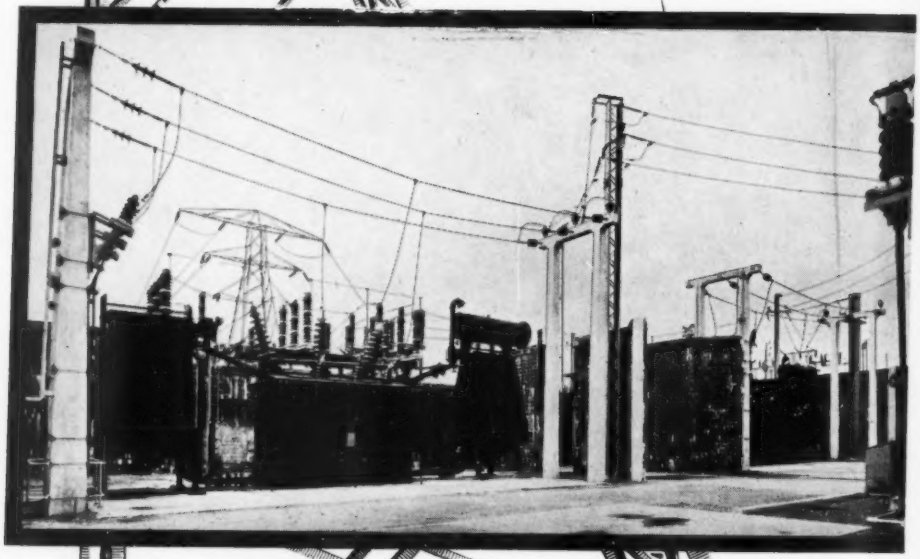
Voith-Hydraulic Turbines for Water Power Plants

Workshop assembly of a split Francis runner. Diam. 16 feet 5 inch. Output 60,000 H.P.

J.M. Voith G.m.b.H., Engineering Works, Heidenheim (Brenz)
Telegrams: Voithwerk Heidenheimbrenz Germany (Württemberg)



TRANSMISSION AND



TRANSFORMERS by G.E.C.

GENERATION · CONTROL · RECTIFICATION · DISTRIBUTION

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

CHRISTIANI & NIELSEN

CIVIL ENGINEERS AND CONTRACTORS—ESTABLISHED 1904

ENTRANCE TO UNDERGROUND HYDRO-ELECTRIC POWER PLANT

Backed by the experience gained during 48 years working in 35 countries, the Christiani & Nielsen Organisation can undertake large-scale civil engineering work of all types in any part of the world.

SPECIALITY: Marine and Hydraulic Structures.

LONDON OFFICE: 54 Victoria Street, S.W.1.
Telegrams: Reconcret, London.

CENTRAL DESIGNING OFFICE: Vester Farimagsgade 41, Copenhagen
Telegrams: Jernbeton, Copenhagen

ALSO OFFICES IN: Aarhus - Asuncion - Bahia - Bangkok - Bogota - Buenos Aires - Cape Town Caracas - Durban - Guayaquil - Hamburg - Helsingfors - Lima - Lourenco Marques - Mexico City Montevideo - New York - Oslo - Paris - Rangoon - Rio de Janeiro - Sao Paulo - Stockholm - The Hague.

In every field
of engineering
BIRSO
TRADE MARK
NON-FERROUS
CASTINGS
are known, used
and esteemed
T. H. BIRKETT & SONS LIMITED · HANLEY · STAFFS
'Phone: Stoke-on-Trent 3184-5-6
In association with
'Grams: Birkett, Hanley
BILLINGTON & NEWTON LIMITED · LONGPORT · STOKE-ON-TRENT
'Grams: Bronze, 'Phone, Longport

Sluderno - Cesano 230 kV Transmission Line: Strain Tower near Stelvio Pass

SAE: OVER 25 YEARS DESIGNERS, SUPPLIERS AND CONTRACTORS FOR:

Power transmission lines
Railway, tramway and trolley-bus contact lines
Overhead and cable telegraph and telephone lines
Electric light and signal installations
Lattice towers for power lines and substation structures
Steel structures for industrial buildings, warehouses and radio towers
Centerings for bridges and frameworks of all kinds
Galvanized fittings for electric lines and substations
Erection equipment

SOCIETÀ ANONIMA ELETTRIFICAZIONE S.p.A.

Via Larga, 8 - Milano (Italy)

Established 1926

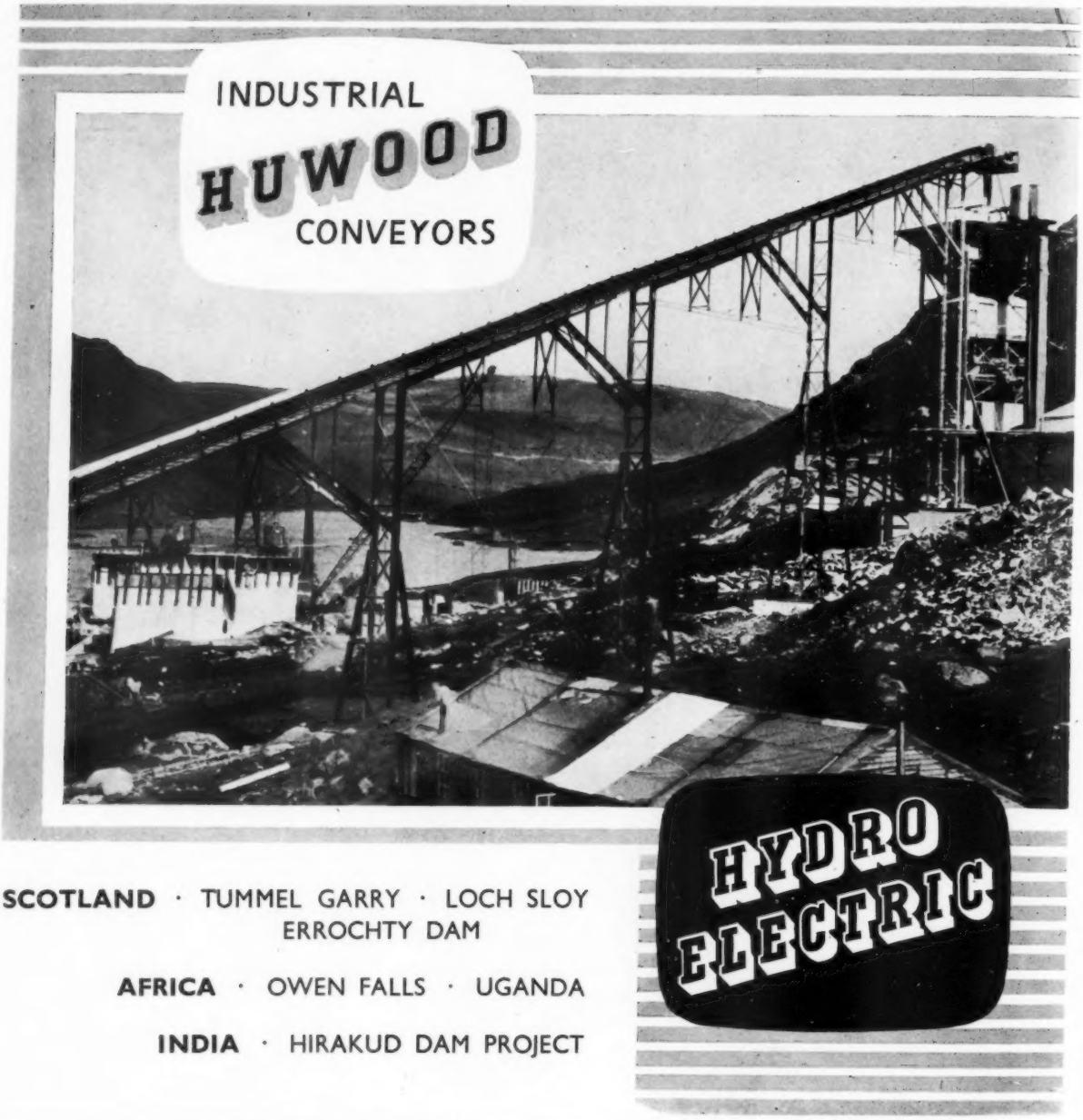
Telephone 898.142 Cables: ELETTROBRENNERO MILANO

London Representative Office: 2 Victoria Street, S.W.1 Telephone: ABBey 7210

Subsidiary Companies, Branches and Representatives throughout the World

Quarry to Batching PLANT

STONE & AGGREGATE



SCOTLAND · TUMMEL GARRY · LOCH SLOY
ERROCHTY DAM

AFRICA · OWEN FALLS · UGANDA

INDIA · HIRAKUD DAM PROJECT

HUGH WOOD & CO. LTD.

HUWOOD

Head Office & Factories : GATESHEAD-ON-TYNE, 11

Industrial & Export Office : DASHWOOD HOUSE, 69, OLD BROAD STREET, LONDON, E.C.2

IND/120C/1

Whatever your
Earthmoving problems

BLACKWOOD HODGE

supply the World's finest equipment

•

EUCLID WAGONS, LOADERS AND SCRAPERS

•

CUMMINS Dependable DIESEL ENGINES

•

MARION EXCAVATORS AND DRAGLINES

•

CARLISLE HEAVY-DUTY ROAD GRADERS

•

CARLISLE DOZING EQUIPMENT

•

BLACKWOOD HODGE

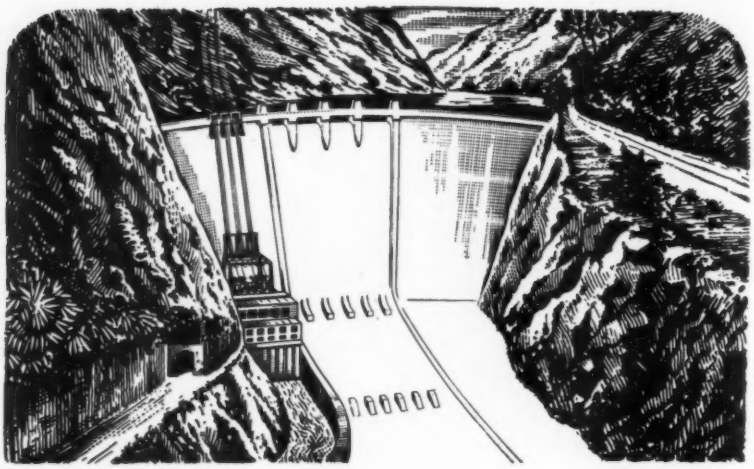
Sales:
11 BERKELEY STREET, W.1
Telephone Mayfair 9090

EUCLID
THE PIONEER

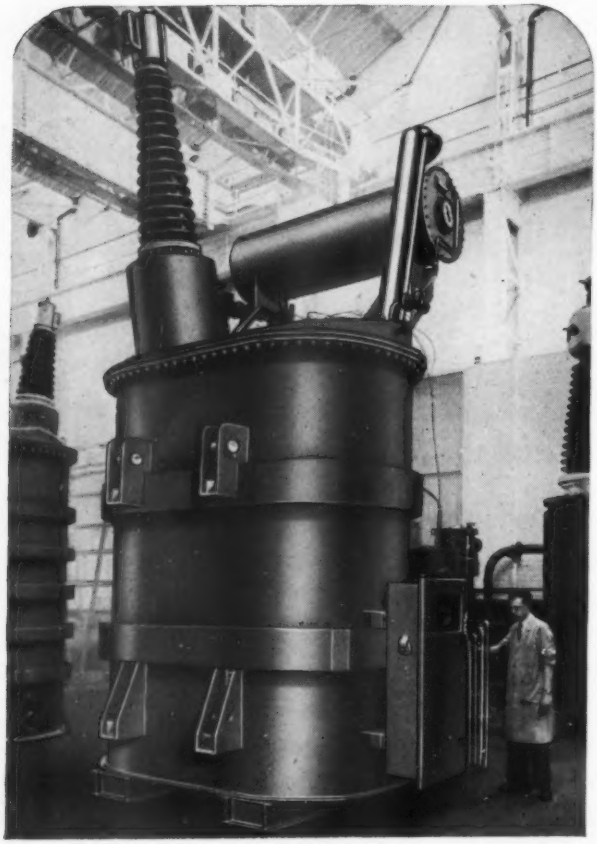
Works & Service:
HUNSBURY, NORTHAMPTON
Telephone Northampton 5262

U.K., U.S.A., IRELAND, BELGIUM, FRANCE, PORTUGAL, SPAIN, ITALY, S. AFRICA, E. AFRICA, W. AFRICA, RHODESIAS & NYASALAND, BELGIAN CONGO, ANGOLA, MOZAMBIQUE, SUDAN, INDIA, PAKISTAN, CEYLON, BURMA, AUSTRALIA

NATURAL
RESOURCES
HARNESSED
by
B
T-H



Hydro-electric Equipment



A natural source of perpetual power lies in the upland lakes and rivers of almost all countries. To harness it, BTH supply all plant required for hydro-electric power schemes. The long experience of hydro-electric engineering possessed by BTH is one reason for the superiority of their equipment. Another is the exceptional capacity of the Rugby works, where plant on a very large scale, such as is required for many hydro-electric schemes, can be built without restriction.

Top: Artist's impression of the Los Peares Power Station, North West Spain.

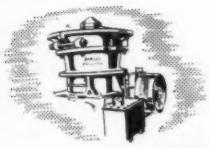
Left: One of the ten 20,500-kVA., single-phase, 50-cycle, Type OFW Transformers (on test in BTH works) forming three 61,500-kVA., 11/132-kV. three-phase banks, plus one spare unit, for the above Power Station.

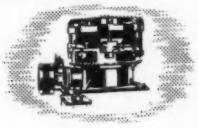
For all plant required for Hydro-electric Power Schemes — **Consult BTH.**

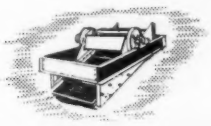
Member of the AEI group of companies

THE
BRITISH THOMSON-HOUSTON
COMPANY LIMITED, RUGBY, ENGLAND

4405







PEGSON

THE PLANT BEHIND THE PROJECT

It is a fitting tribute to the reliability of Pegson Plant that it has been chosen for many of the major international irrigation and hydro-electric projects, some of which are listed above.

INFORMATION
Specially prepared leaflets describing Pegson Plant in detail are available. Write for copies.

PEGSON LTD. IDDESLEIGH HOUSE, CAXTON STREET, LONDON S.W.1
WORKS: COALVILLE, LEICESTERSHIRE. TELEPHONES: ABBEY 2373. COALVILLE 234
A COMPANY OF THE MELLOR BROMLEY GROUP

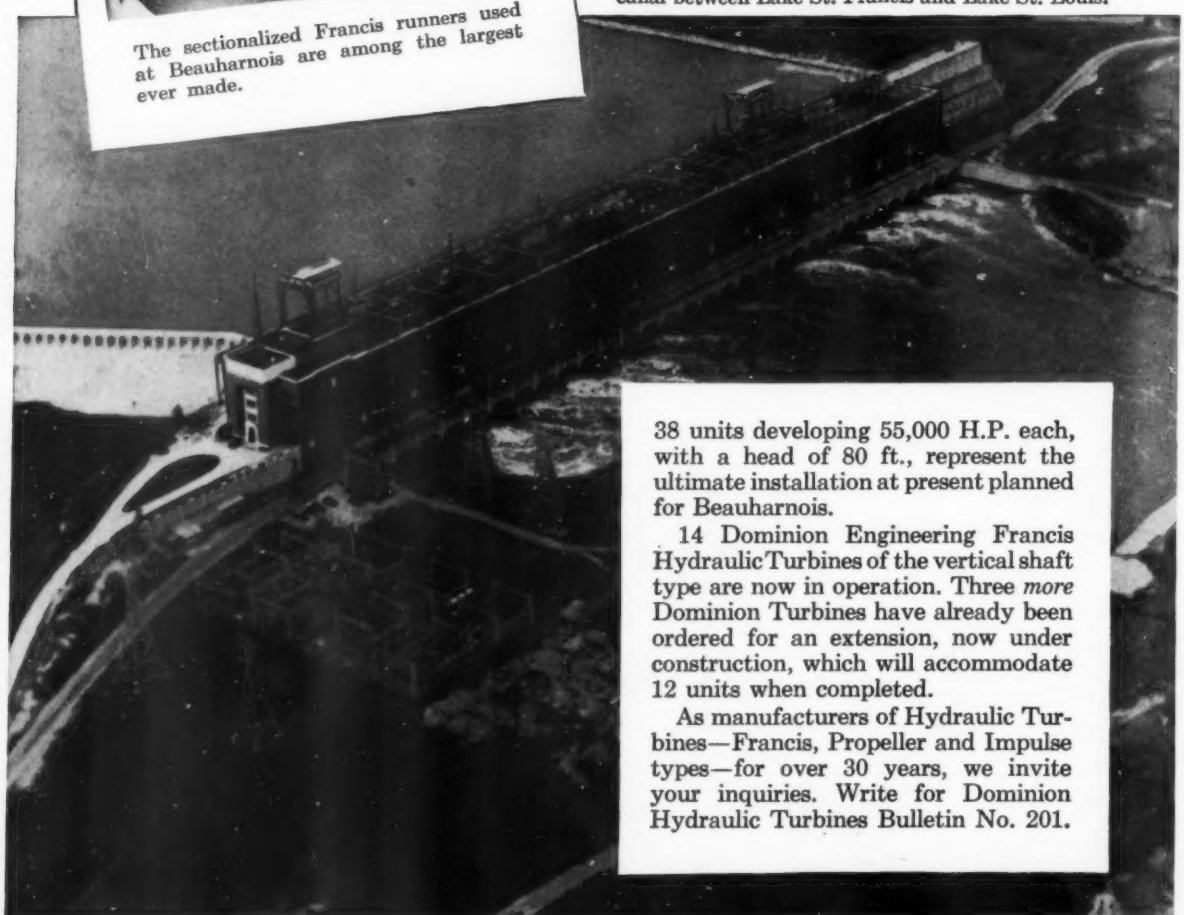
Ultimate Development of over 2,000,000 H.P. in one Canadian Plant

Dominion Engineering

Hydraulic Turbines

The sectionalized Francis runners used at Beauharnois are among the largest ever made.

The Quebec Hydro Electric Commission controlled power installation at Beauharnois near Montreal, at the down stream end of the 15 mile long, three quarter mile wide canal between Lake St. Francis and Lake St. Louis.



38 units developing 55,000 H.P. each, with a head of 80 ft., represent the ultimate installation at present planned for Beauharnois.

14 Dominion Engineering Francis Hydraulic Turbines of the vertical shaft type are now in operation. Three *more* Dominion Turbines have already been ordered for an extension, now under construction, which will accommodate 12 units when completed.

As manufacturers of Hydraulic Turbines—Francis, Propeller and Impulse types—for over 30 years, we invite your inquiries. Write for Dominion Hydraulic Turbines Bulletin No. 201.

DOMINION ENGINEERING
COMPANY LIMITED

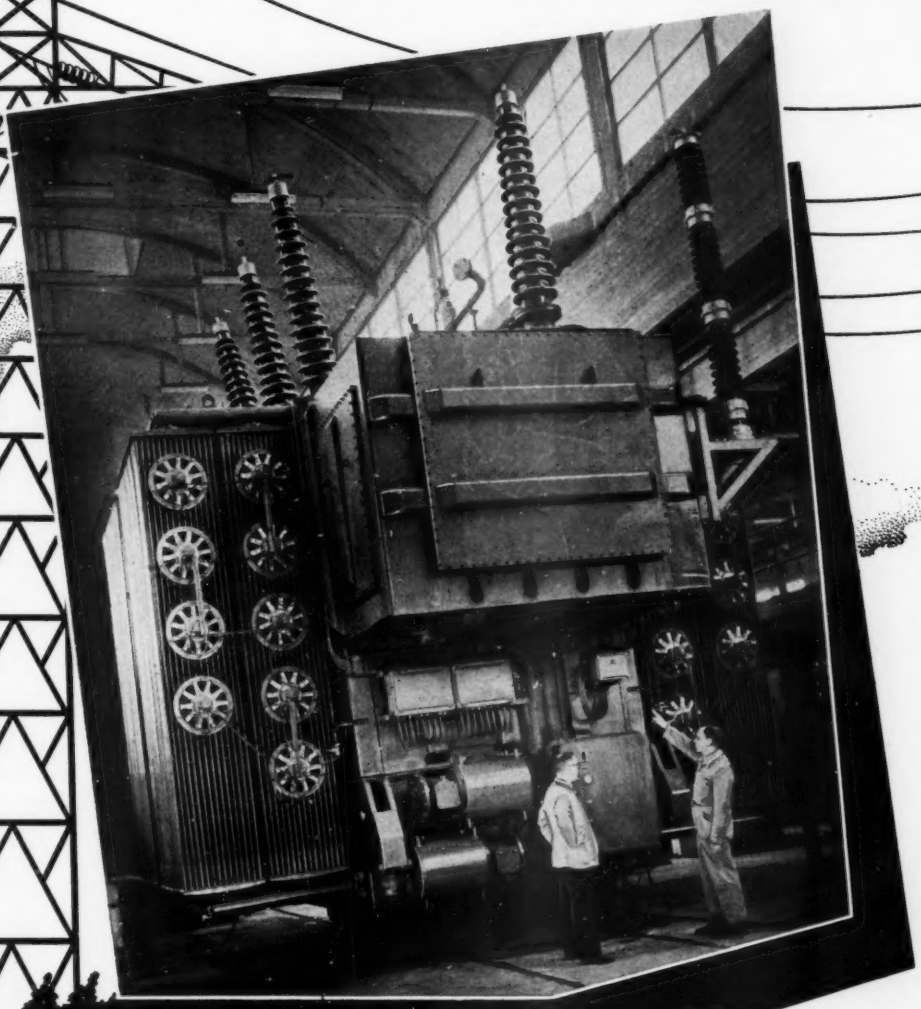
MONTREAL, CANADA

CABLE: DOMWORKS

One of the 4 TRANSFORMERS

"Shell-Type"

OF 75 000 kVA, INTENDED FOR THE BELGIAN CENTERS OF INTERCONNECTION FOR NETWORKS OF 150/70 kV.



75 000 kVA

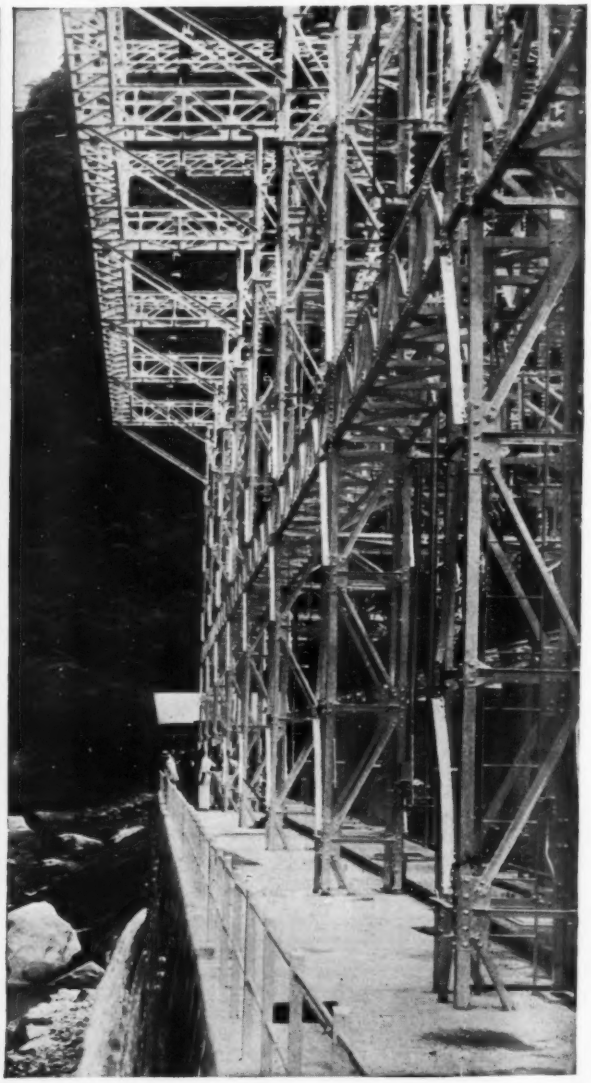
3 WINDINGS : 150/70/10 kV.
ON LOAD VOLTAGE REGULATION : ± 17,5 % ON THE 150 kV SIDE
3 RANGES OF LOAD : 45 000 kVA - 60 000 kVA - 75 000 kVA according to the type of cooling system.

Ateliers de Constructions Electriques de Charleroi

CHARLEROI C E C

S.P.P. Post Insulators were specified for the 110kv outdoor switchgear on the Jog Falls Hydro-electric Scheme

The outdoor switchgear at Jog Falls Power Station, in Mysore State, India, equipped with S.P.P. Cylindrical Post Insulators type P.701.



STEATITE & PORCELAIN PRODUCTS LTD.

Stourport-on-Severn, Worcestershire Telephone: Stourport 111 Telegrams: Steatain, Stourport

S.73

ONE FAMILY Management

Our three generations of experience in management is useful to you because it has assured the continued and uninterrupted advancement of our company which is reflected in its present reputation as well as its financial stability and unexcelled manufacturing facilities.

As builders of hydraulic turbines, pumps, gates, hoists and automatic valve equipment for the past 77 years, we are in a position to assist you in the solution of any related problem you may have.

S · MORGAN SMITH
C O M P A N Y
YORK
PENNSYLVANIA
U·S·A·

If It's Hydraulics-
Put It Up to Us!

POWER by SMITH

BRUCE PEEBLES

TRANSFORMERS

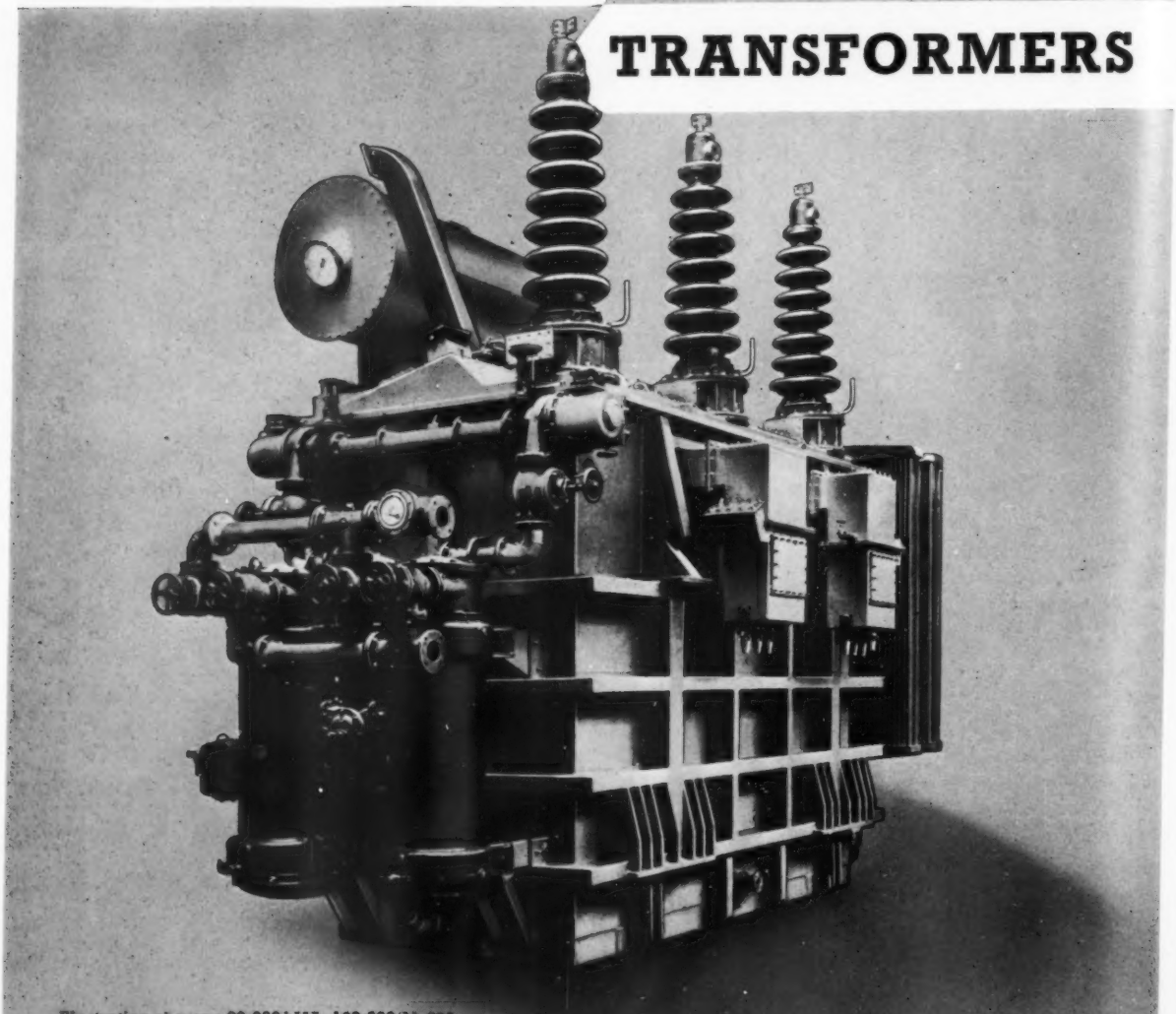


Illustration shows a 20,000 kVA, 132,000/11,000-volt water-cooled transformer typical of many supplied for Scottish hydro-electric schemes.

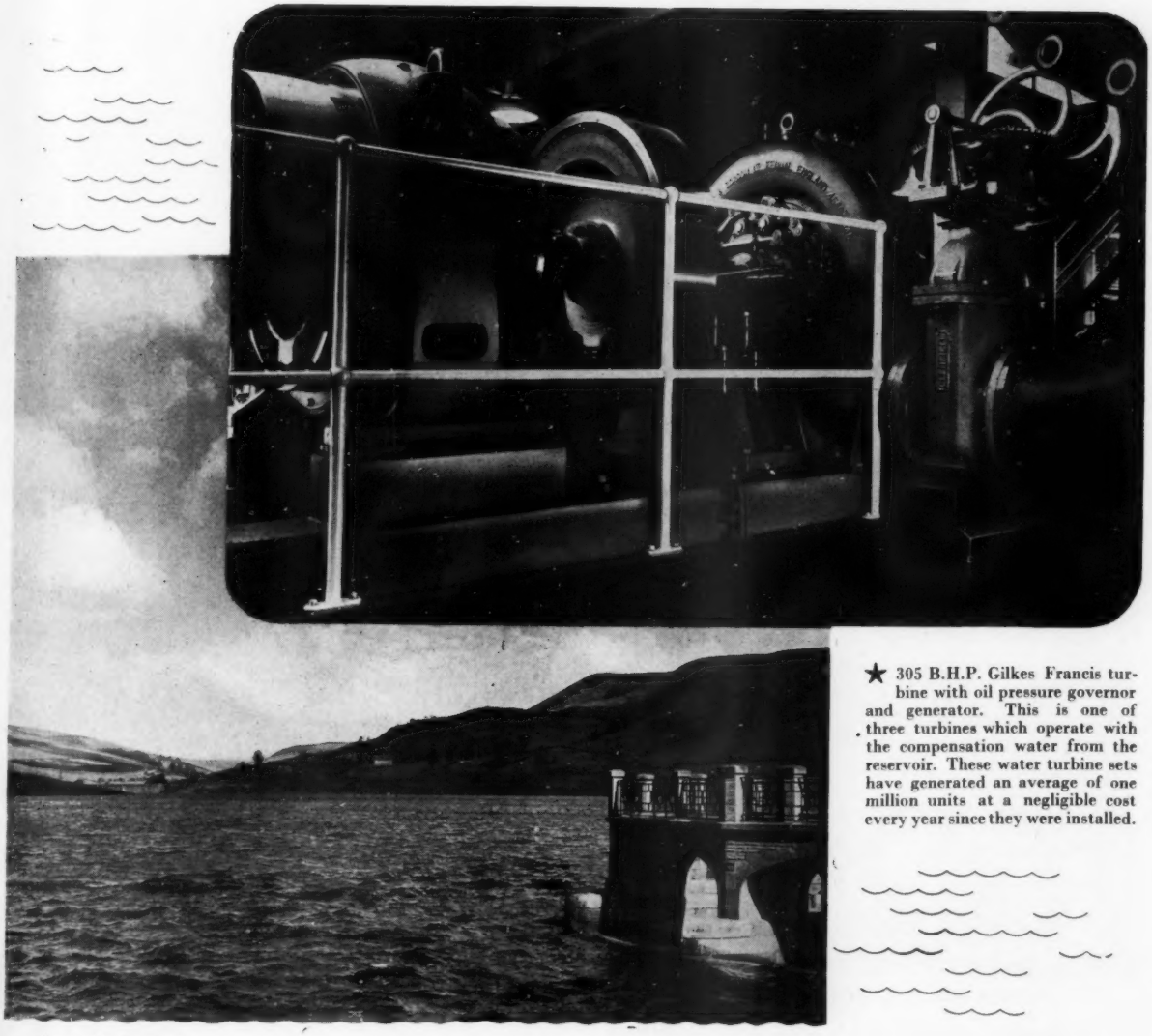
PEEBLES **TRANSFORMERS running into millions of kVA in units up to 75,000 kVA have been supplied for use all over the world, and larger equipments for the British Super-Grid are now on order.**

In practically every country you will find Bruce Peebles Transformers ranging from small pole mounting type to large power units.

BRUCE PEEBLES & CO. LTD., ENGINEERS, EDINBURGH

GILKES WATER TURBINES

at the Ladybower Reservoir, Ashopton, Derbyshire



★ 305 B.H.P. Gilkes Francis turbine with oil pressure governor and generator. This is one of three turbines which operate with the compensation water from the reservoir. These water turbine sets have generated an average of one million units at a negligible cost every year since they were installed.

At the Ladybower Reservoir, one of the largest stretches of artificial water, the Derwent Valley Water Board has installed three Gilkes Water Turbines totalling 660 B.H.P.

Write for GILKES handbook: "On the Development of Water Power"

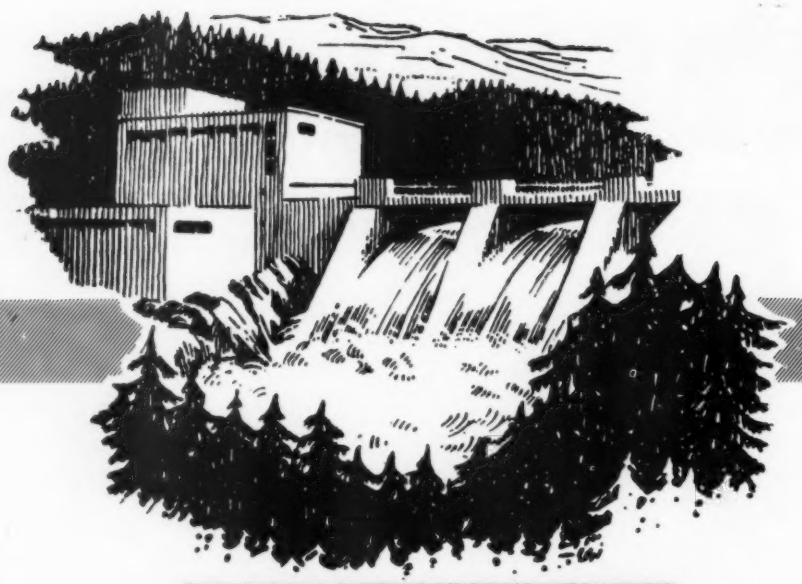
GILBERT GILKES & GORDON LTD

KENDAL *'Phone: Kendal 28* ENGLAND

WATER TURBINE AND PUMP MANUFACTURERS

London Office: CRAVEN HOUSE, KINGSWAY, LONDON W.C.2 *'Phone: Holborn 3232*

G.29



NOHAB

WATER TURBINES

WATER TURBINES have been manufactured at our works for more than

100 years

One of the first turbines, constructed in 1848 for a flour mill, is still in service —a noteworthy record.

At the present day we have possibilities to build turbines with runners up to

30 feet in diameter

At the Harsprånget plant in northern Sweden there are now two NOHAB turbines running, each developing a power in excess of

150,000 h.p.

Our production includes:

GOVERNORS for automatic and semi-automatic control, also of the **ASEA-NOHAB** electro-hydraulic type.

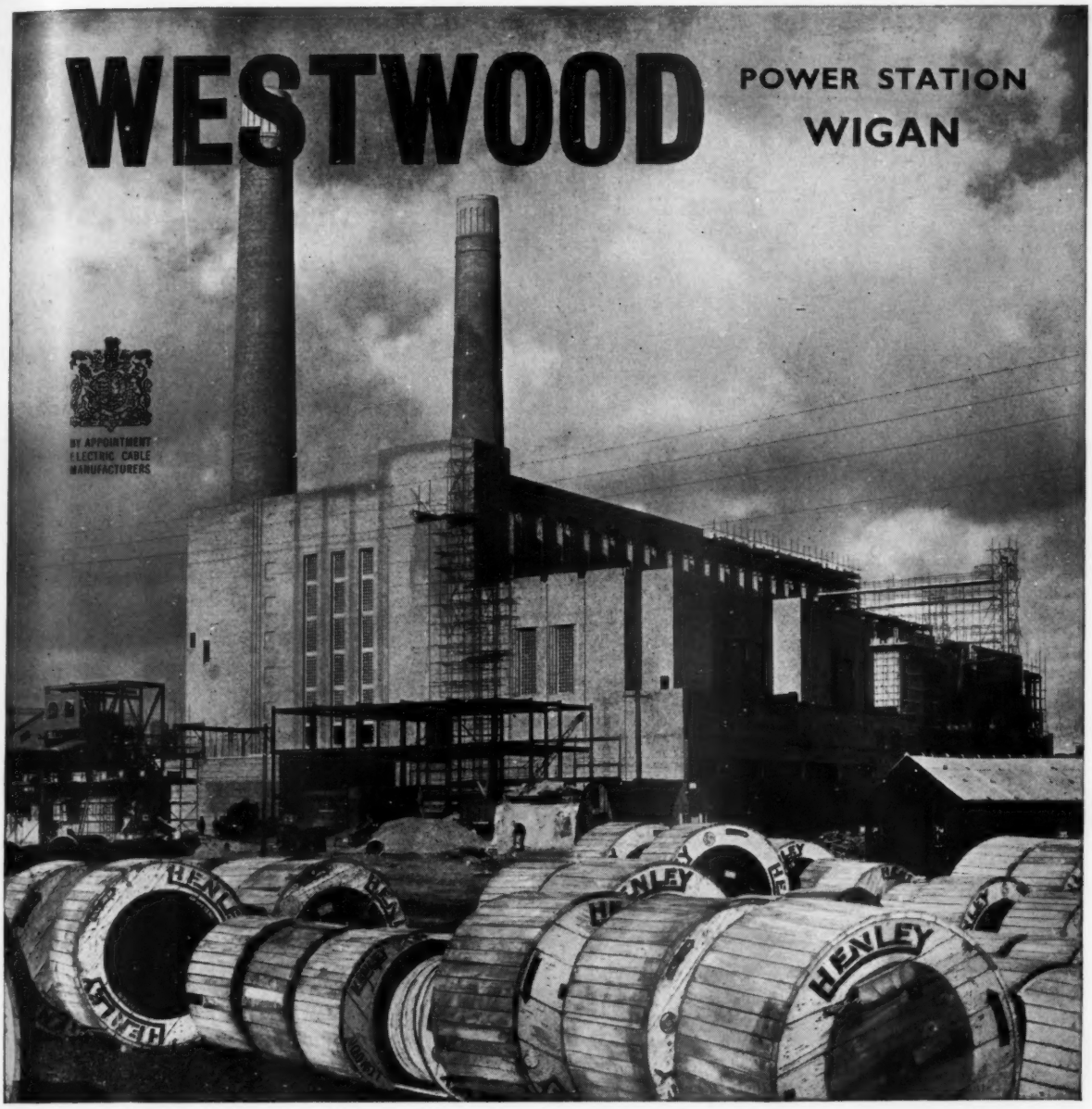
CONTROL VALVES of various types: Butterfly, spherical, Johnson.

GATES and other mechanical equipment for power plants.

NYDQVIST & HOLM AKTIEBOLAG

TROLLHÄTTAN, SWEDEN

Telegrams : Nohab, Trollhattan

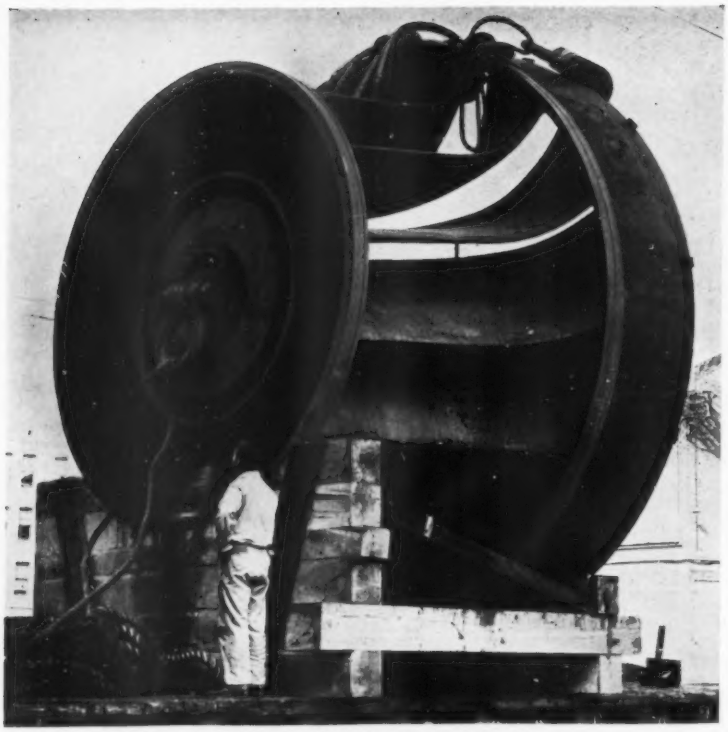


HENLEY'S were responsible for the entire cabling installation at Westwood Generating Station, Wigan.

HENLEY CABLES

Consulting Engineers: Kennedy & Donkin

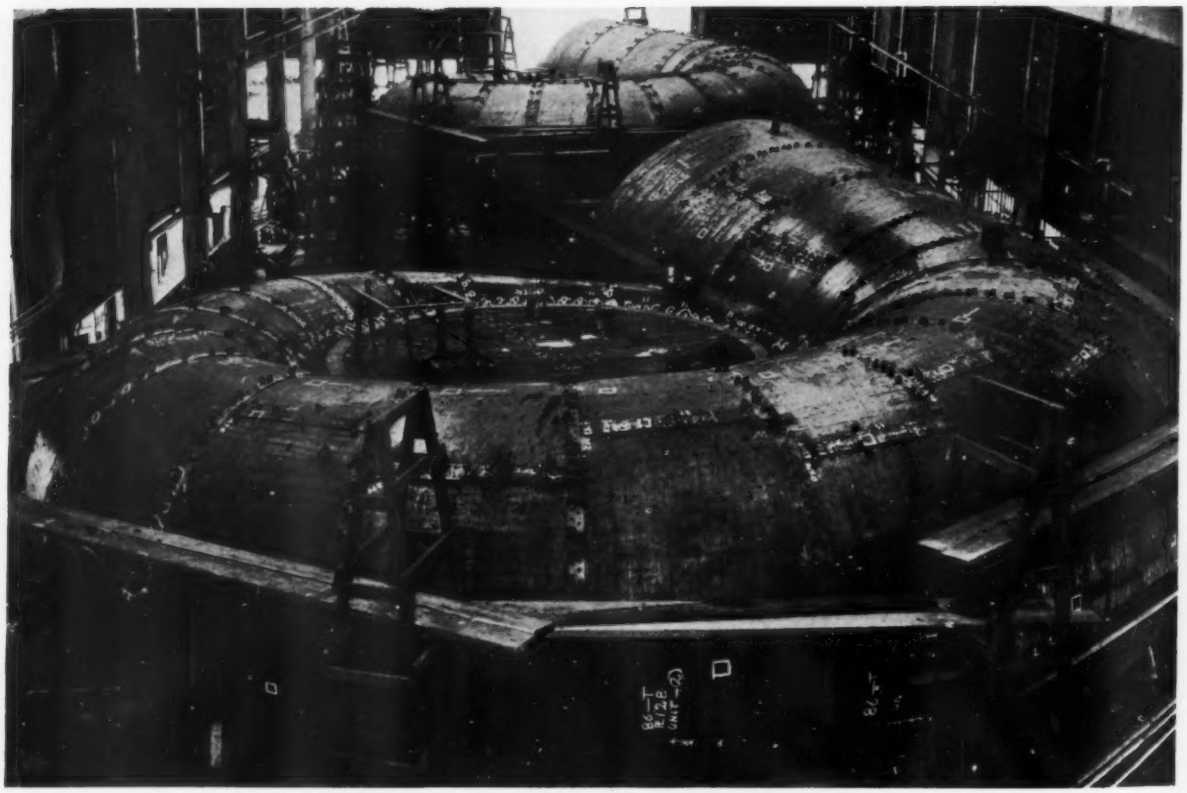
W. T. HENLEY'S TELEGRAPH WORKS CO. LTD., 51-53 HATTON GARDEN, LONDON, E.C.1



RUNNER FOR BUGGS ISLAND DEVELOPMENT

OVER EIGHT MILLION HORSEPOWER

The Newport News Shipbuilding and Dry Dock Company has received orders for the building of hydraulic turbines aggregate rated output of 8,135,000 horsepower.



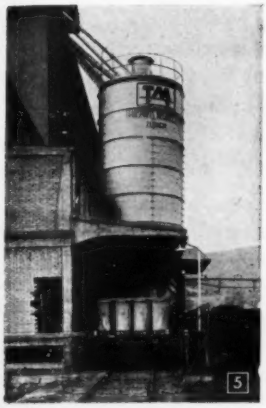
ASSEMBLY OF SPIRAL CASINGS FOR C. J. STRIKE DEVELOPMENT

NEWPORT NEWS
SHIPBUILDING AND DRY DOCK COMPANY
Newport News, Virginia

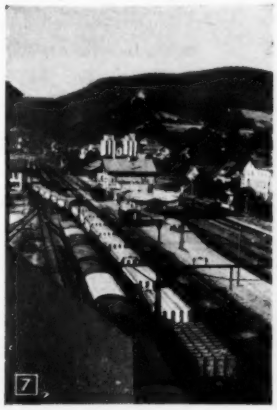
All problems of the transport of cement in bulk are solved by applying the system

The transport of cement in bulk by the patented system TM assures considerable advantages of which the most important are:

1. — Elimination of transportation bags.
2. — Elimination of cement losses during transport.
3. — Efficiency of handling during transshipment.
4. — Elimination of the need for sheds at the points of transshipment.
5. — Most efficient utilization of transport facilities, due to the ease and rapidity of the operations of loading, unloading and transloading.



Filling of the containers at the cement factory



Transport by train of flatcars equipped by TM

Transport by lorries equipped by TM

Transport by ropeways

Transloading rail/road by equipment designed for ease of handling

Transloading rail/road by interposing a roller-ramp

TM-TRANSPORTS MÉCANISÉS S.A. ZURICH Bannhofstr. 24

Leffel

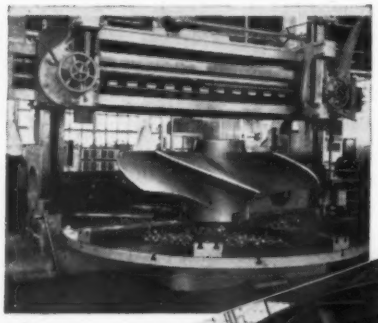
HYDRAULIC TURBINE

increases

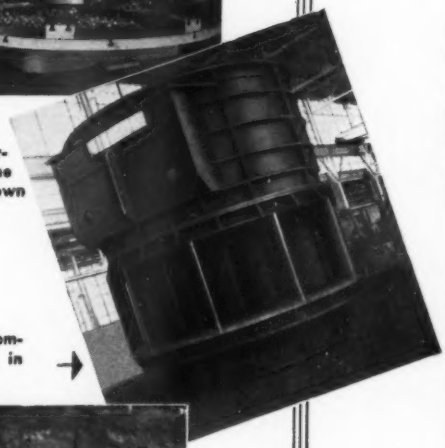
power output at

WILBUR DAM

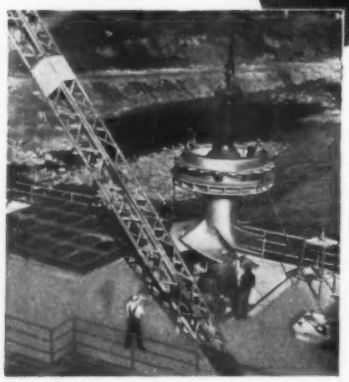
of the Tennessee Valley Authority



Cast steel propeller-type runner for the Wilbur turbine, shown on boring mill.



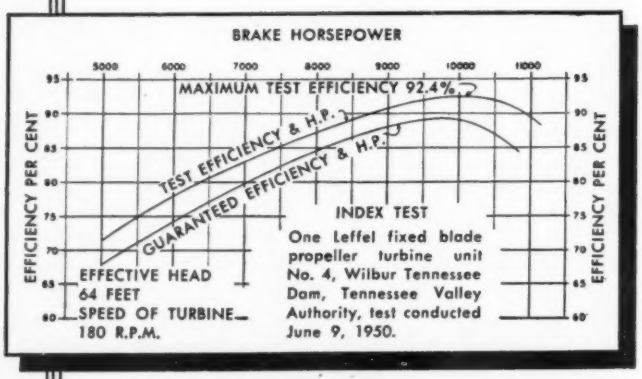
Wilbur turbine, completely assembled in the Leffel plant.



Lifting the combined runner, shaft and cover-plate during the field installation.

The Wilbur power project of the TVA is another instance where a Leffel hydraulic turbine was used for the expansion of existing power facilities. For the Wilbur installation a Leffel vertical propeller-type hydraulic turbine was used — maximum rated at 11,500 HP, under 67 feet net head, speed 180 RPM.

The Wilbur project demonstrates once again that the long-range economy and dependability of Leffel turbines make a valuable asset for any expansion or rehabilitation. Our facilities are backed by 90 years of reliable service to the water power industry. Why not let us help you with your project, whether it be expansion, rehabilitation or a new installation?



Field Test Results

1082

FOUNDED IN 1862

THE JAMES LEFFEL & CO.

DEPARTMENT W • SPRINGFIELD, OHIO, U. S. A.

MORE EFFICIENT HYDRAULIC POWER FOR 90 YEARS

Remote supervisory control

BROWN BOVERI

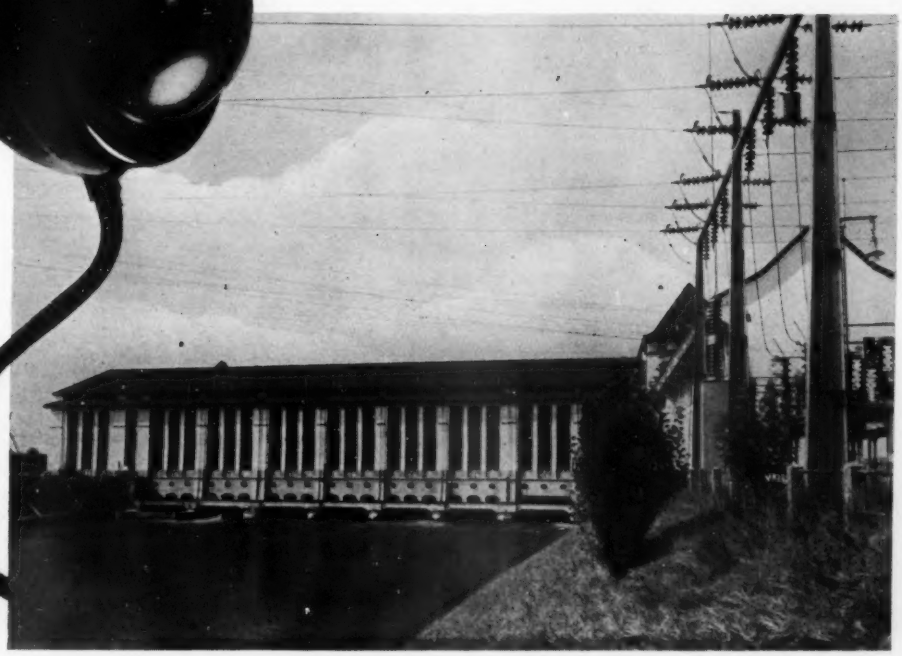
Carrier channels over high-voltage lines

Telemetering
by the proved frequency-variation process

Remote supervisory control
of complete power and distribution stations

Circuit-breaker intertripping schemes
with carrier channels over high-voltage lines

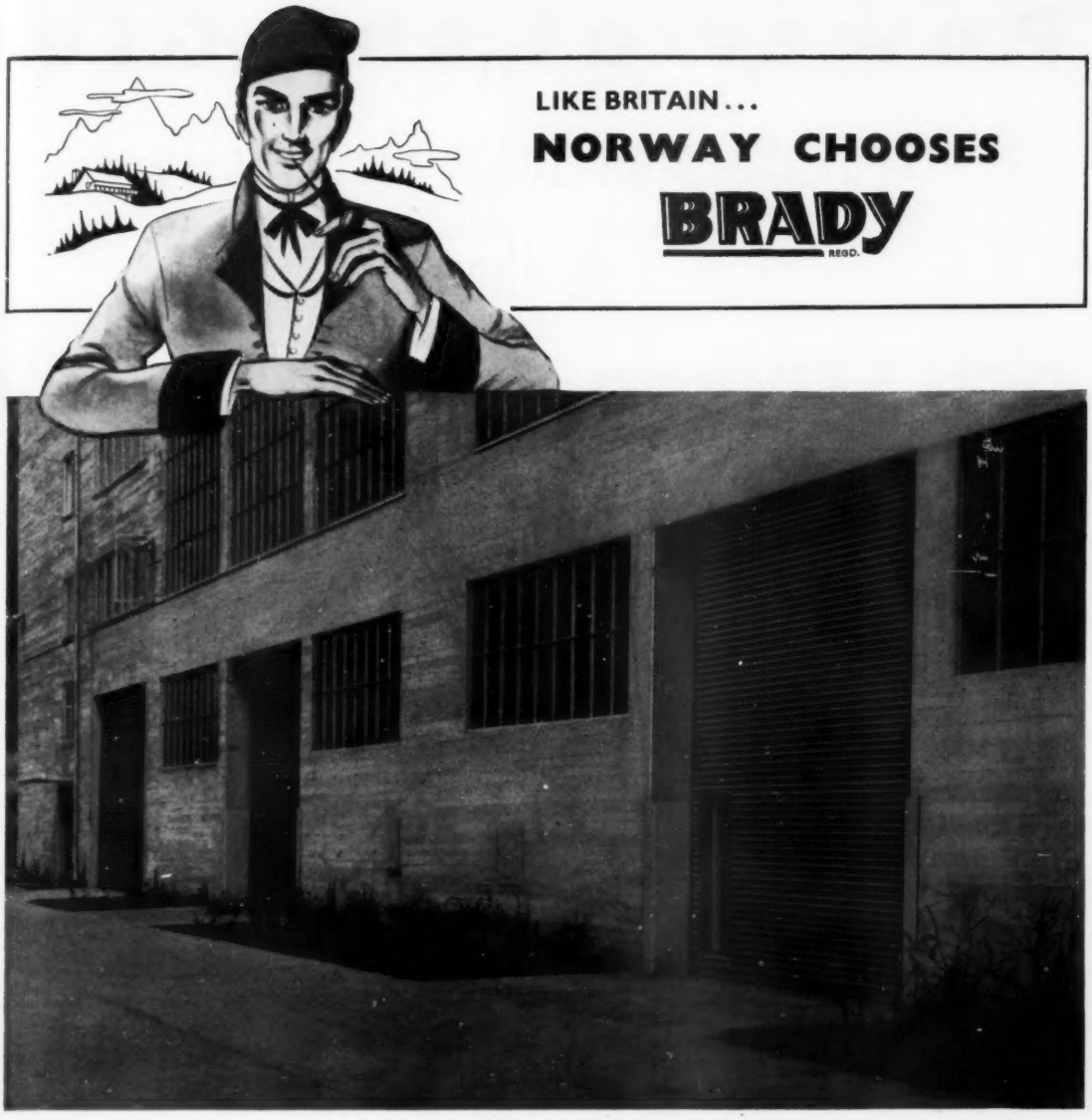
BROWN, BOVERI & CO. LTD.
BADEN, SWITZERLAND



75364 · X

Essential to the construction of the big jobs
Henderson
AERIAL CABLEWAYS
for Hydro-Electric Schemes
Night and day in all weathers Henderson Aerial Cableways consistently maintain scheduled construction programmes. The speed, economy and efficiency of Henderson Cableways are essential factors in large building, constructional and hydro-electric undertakings. Henderson Cableways were used for the construction of the Dams at Loch Sloy and Glen Shira, North Scotland, Hydro-Electric Board, and various other home and overseas undertakings.

JOHN M. HENDERSON AND COMPANY LIMITED · KING'S WORKS · ABERDEEN Phone 24262



"Brady" is a by-word in most countries now. This installation of three gear-operated steel shutters, incorporating a wicket gate, was supplied to An. Thorbjornsen of Oslo, to give maximum clearance and accessibility at loading points. Whenever it's a question of moving or storing goods and vehicles — quickly, safely, economically — you'll find the Brady organisation has a straightforward answer.

We shutter the world

BRADY REGD.

G. BRADY & CO. LTD · ANCOATS · MANCHESTER 4 · Phone: COLlyhurst 2797/8
LONDON: New Islington Works, Park Royal N.W.10 BIRMINGHAM: Rectory Park Road, Sheldon 26
CANADA: G. BRADY & CO. (CANADA) LTD., 1405, Bishop Street, Montreal 25.

Manufacturers of Brady Hand and Power Operated Lifts

S & B

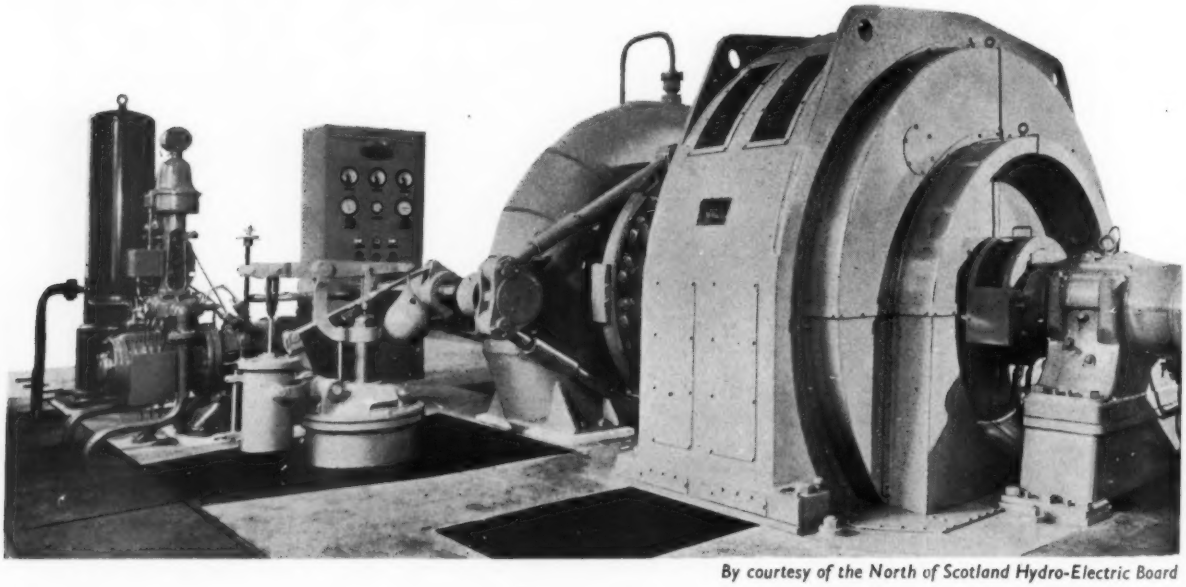
★Power of the Glen

Transformed into Electricity

at the

Loch Striven Power Station

of the North of Scotland Hydro-Electric Board



By courtesy of the North of Scotland Hydro-Electric Board

This power station contains 2 - 4250 b.h.p. "Harland-Morgan Smith" Francis Turbines driving 3529 kVA "Harland" Alternators—a fine example of hydraulic and electrical generating plant manufactured under one roof and erected at site by Harland specialist Engineers.

THE HARLAND ENGINEERING CO. LTD.

FOR HYDRO-ELECTRIC PLANT

★ Translation of the North of Scotland Hydro-Electric Board's Gaelic motto "Neart Nan Gleann".

WATER POWER

A technical journal devoted to the study of all aspects of Hydro-electric developments

Annual Subscription: 35 shillings. Single Copies 2s. 6d.

VOLUME 4. NUMBER 7.

CONTENTS FOR JULY, 1952

Leading Article: C.I.G.R.E. 1952 - - - 241

Editorial Notes - - - - - 242

The Malgovert Tunnel - - - - - 244
By Dr. Charles Jaeger

International High-Tension Conference—I - - 251
By J. H. M. Sykes

The Papanasam Scheme - - - - 255
By R. Dorai Rajan

Water Power in the Faroes - - - - 261

Hydro Developments in Mysore - - - 262

The Central Valley Project—II - - - - 263
By Stephen H. Poe

Power Problems in Japan - - - - 267

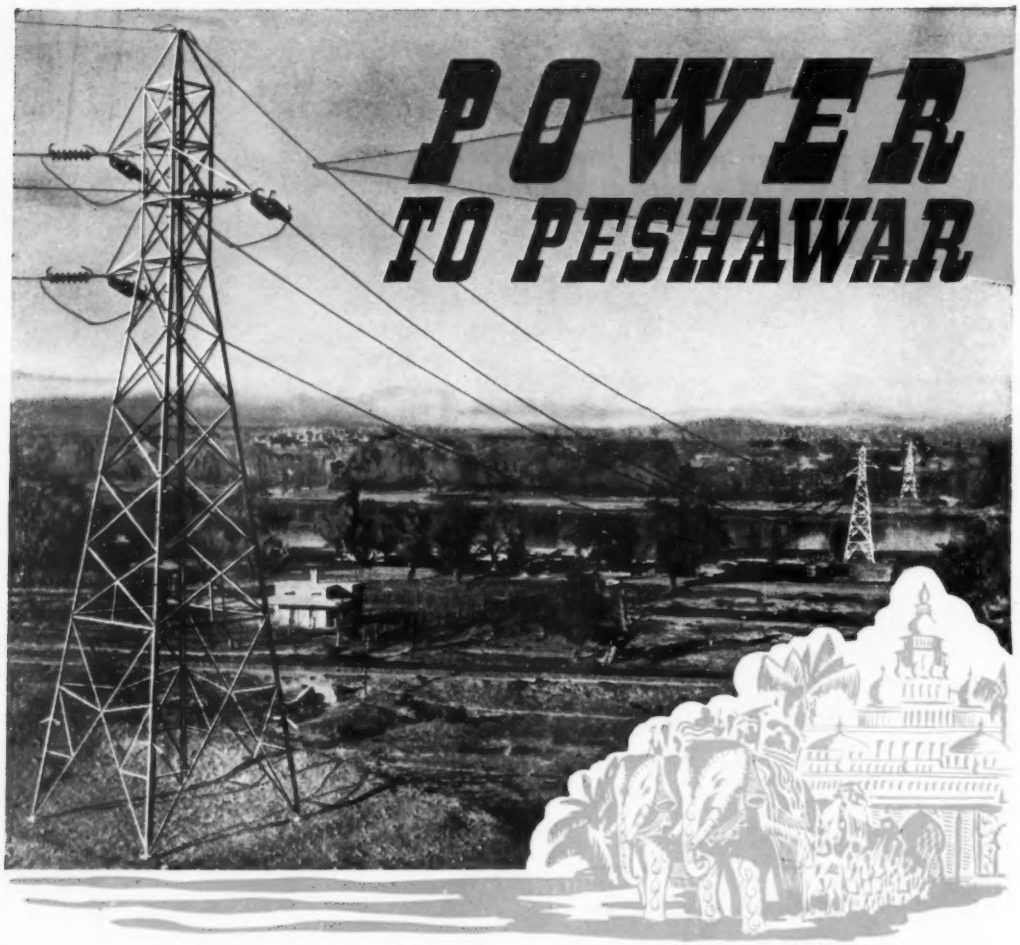
The Glen Affric Scheme—III - - - - 270

Book Reviews - - - - - - 275

Short Articles - - - - - - 276
Galion Motor Graders — Measuring Movement in Buildings

Abstracts from the World Technical Press - - 278

Published by
Tothill Press Limited,
33 Tothill Street, Westminster, London, S.W.1.
Telegrams: Ishbuilder, Parl, London. Telephone: Whitehall 9233 (12 lines).
MANCHESTER: Century House, St. Peter's Square. Telephone: Central 3101.
BIRMINGHAM: 90 Hagley Road, Edgbaston. Telephone: Edgbaston 2466.
NEWCASTLE-ON-TYNE: 21 Mosley Street. Telephone 22239.
GLASGOW: 87 Union Street. Telephone: Central 4646.
LEEDS: 70 Albion Street. Telephone 27174.
BRISTOL: 8 Upper Berkeley Place, Clifton.



Water from a tributary of the River Indus provides power for the Malakand hydro - electric station, high in Pakistan's North West Frontier Province.

To bring current down to Peshawar and its neighbouring districts, BICC erected over a hundred miles of 66 kV single and double circuit overhead power transmission lines for the Public Works Department.

The grid system crosses rivers, railways and difficult mountain country. It was surveyed and planned by BICC technicians, who also installed the transmission equipment designed and manufactured in the Company's own factories in the U.K.

Wherever the need for high voltage transmission, advantage should be taken of the experience and vast manufacturing resources of the BICC world wide organization.

BI Callender's OVERHEAD TRANSMISSION

BRITISH INSULATED CALLENDER'S CABLES LIMITED
NORFOLK HOUSE, NORFOLK STREET, LONDON, W.C.2

Branches and Agents throughout the World

WATER POWER

A technical journal devoted to the study of all aspects of Hydro-Electric Development

C.I.G.R.E. 1952

THE 1952 C.I.G.R.E. Conference opened in Paris with a lecture by Mr. Rusck, Director General of the Swedish State Power Board, describing the inauguration of the world's first 380 kV transmission line, which has been described in these columns.

The concentration of interest on the design of transmission lines at higher voltages and with larger capacities was a prominent feature of this year's C.I.G.R.E. The need to bring under control water power resources at vast distances from the centres of industry is becoming an urgent matter in many countries, and even if the Swedish achievement stole the limelight, in view of the great length and the high voltage involved in this particular project, the papers dealing with overhead lines and cables showed that many countries are aware of the need for rapidly reinforcing their transmission systems.

The American engineers who came to Paris held the view that a voltage which may be of the order of 330 kV is probably sufficient for any forseeable increased transmission requirements in the United States. It is perhaps a little unfortunate that they should have found it necessary to adopt a voltage which is not among the recommended standards which have been agreed on by most of the European countries. It was noticeable in reading through the American papers that in the lengthy lists of references to previous sources of technical information, almost without exception the whole of their references were exclusively confined to American practice.

It will be necessary for many years to come to utilise steel, copper and other materials the electrical engineer needs in the most efficient manner possible; and if world trade is to be stimulated in the way that every Government hopes the greatest measure of standardisation possible is obviously a most desirable feature.

In the alternator field some of the papers were aimed at assisting in standardisation for alternators, even if this is a very difficult matter for the designers of the generators associated with hydraulic turbines. Nevertheless, it is a move in the right direction, and comment made during informal discussions at C.I.G.R.E. showed that the majority of the engineers concerned with all aspects of electrical transmission are realising the importance of standardisation to a greater degree than ever before.

A welcome trend was seen in the transformer discussions, many of which sought to obtain greater output from a given use of active materials. The ageing of transformers under overload conditions, and the effects on the insulation of long-term and short-term overloads, have been of much discussion at C.I.G.R.E. and elsewhere in recent years. This year's session subject served to focus attention on the amount of work that has already been done, and also to indicate where further research is necessary in regard to this problem; and it may very well be that in the future international agreement will be reached on a specification for large power transformers, which will indicate that much greater use under controlled conditions may be made of a given unit. The greater use of transmission lines by the addition of series capacitors, in view of the successful experience in America and in Sweden, both at 220 kV, is again another instance of the focus of attention on the better utilisation of active materials.

The breadth of the field of electrical engineering knowledge is now so great that its boundaries can only be pushed forward by fractional amounts; an occasion like the C.I.G.R.E. conference helps to crystallise recent research and technical progress. On this occasion, as in the past, an enormous number of detailed encroachments over the edge of known facts were made, nothing perhaps entirely new, but leading in the main to reducing the cost and improving the efficiency of the apparatus used for the transmission of power.

Elsewhere in this issue we are commencing a detailed summary of the contents of those papers given at the C.I.G.R.E. Conference which are of interest to engineers concerned with those electrical problems arising in hydro-electric practice.

Volta River Project

A FURTHER step towards the realisation of the Volta River project was made last month when talks took place between officials from the Gold Coast and representatives of the Government, Aluminium Limited of Montreal and the British Aluminium Co. Ltd. It is understood that the interested parties will shortly be making an inspection of the site in conjunction with the consulting engineers, Sir William Halcrow & Partners. The intention is to harness the Volta river for power production with a view to exploiting a convenient deposit of bauxite and producing aluminium to the amount of over 200,000 tons per annum. It is estimated that some 550,000 kW will be available, 500,000 kW of which will be used for the manufacture of aluminium while the remainder will be available for general consumption. The artificial lake created will have a superficial area of over 2,000 sq. miles and will open up long stretches of the Volta river for steamer transport. Necessary ancillaries to the scheme will be railway lines between the bauxite deposits and the smelting plant, and with the new port to be constructed at Tema. The most recent estimate put the cost of the scheme at £80 million.

Tenryu River Development in Japan

THE Tokyo Electric Power Company and the Chubu Electric Power Company are now forwarding preparations to establish a firm to undertake the development of Tenryu river power sources. Both firms, which have received the approval of Joji Matsumoto, chairman of the National Public Utilities Commission, will shortly hold a general meeting of sponsors.

The proposed Tenryu River Development Company is aimed at power development at Sakuma and Akiba on the river. The generating capacity after completion will be 436,000 kW, including 350,000 kW for Sakuma power plant and 86,000 kW for Akiba power station.

The cost of construction is estimated at Y80,000 (about £80) per kW, a price which is about Y20,000 (£20) lower than the average cost.

Construction is estimated to be complete in about three years' time. From the viewpoint of generation capacity, construction cost, and construction period, the two sites are regarded as being highly suitable for power development.

Cement Economy

IN common with other organisations the North of Scotland Hydro-Electric Board are making continual efforts to economise in the use of scarce materials. Steel has been saved at Affric and will be saved on the Shira, Errochty and Garry-Moriston schemes by substituting underground pressure tunnels for pipelines running down the hillside. For normal building purposes local stone is being used in preference to brick, cement and steel, all of which have to come from some distance, and where the sites are suitable rock-fill and morraine-fill dams are being constructed in preference to concrete. Although the cost will be about the same it is estimated that the construction of the Quoich and Glascarnoch dams by rockfill methods will result in a saving of 48,000 tons of cement. A further interesting experiment concerns the substitution of finely ground blast-furnace slag for a proportion of the cement used in the particularly large dams of the Moriston scheme at the outlets of Loch Loyne and Loch Cluanie. Some particulars of this method—known as the Trief process—were given in this journal last month.

Wicklow Project

THE Wicklow village of Annamore, about 30 miles from Dublin, is expected to be submerged if the latest plan of the Electricity Supply Board for further hydro-electric development is carried out. A tentative scheme has already been approved in principle by the Board and the necessary preliminary surveys are in progress. The new plan, which would increase the Electricity Supply Board's total output by 35 million kWh, envisages the utilisation of the waters of Lough Tay and another lough for generating purposes and the possible diversion of part of the Annamore river to provide supply for Wicklow town and district. Not only would part of Annamore probably be submerged as a result of the erection of the dam less than a quarter of a mile away on the Glendalough side but also about a mile of the main road, necessitating the building of a new road at a higher level.

Indian Projects

MR. SRI PRAKASA, Indian Minister for Natural Resources and Scientific Research, told Parliament recently that the Planning Commission had listed 102 irrigation and hydro-electric projects of which 68 were under construction. The remaining 34 were proposed to be started in the five-year period.

The new target dates fixed for the completion of major projects now under construction were as follows: Bhakra Nangal 1958-59, Machkund hydro-electric scheme 1953, Tungabhadra 1954, Hirakud stage one 1955-56, Kakrapar weir and canal project 1953-54, Mayurakshi project 1954, Sarda power house scheme 1953-54, and Damodar Valley first phase 1957-58.

The Finance Minister said that the Kosi project was likely to be included in the second part of the Five-Year Plan. (The second part relates to the projects that are to be executed in case foreign assistance is available.) The original proposal was to build a dam at Barakshetra, five miles above Chatra. The dam was to be 783 ft. above the rock foundation and to provide a power capacity of 1·5 million kilowatts It was to take 12 years for completion. That scheme was found to be unsuitable by the expert committee, which had evolved a new scheme. The proposed dam would be of medium height and would be built at Balka, nine miles farther downstream. It would have a hydraulic height of 85 ft. and a storage capacity of 1·8 million acre-feet. It would irrigate 400,000 acres of land in Nepal and 2·27 million acres in Bihar. It would be possible to generate 91,000 kW, but for the present it was proposed to provide for only 40,000 kW in the first stage. The estimated expenditure was Rs. 660 million.

Replying to discussions on the Punjab Appropriation Bills (which were subsequently voted by Parliament), the Finance Minister said that the Nangal dam in Punjab had been very nearly completed and

two-thirds of the earthwork was finished on the Nangal hydro-channel. The Bhakra dam would be completed by the end of 1959. More than half the masonry work on the Nangal dam had been completed and the station would start functioning at the end of 1953 so as to supply power in 1954. A large part of non-perennial supply of water would be available in 1954, but the perennial supply could not be made available till the Bhakra dam was raised to two-thirds of the projected height.

Venezuela

THE industrialisation of Venezuela is becoming a matter of interest to engineers from many parts of the world, in view of the large iron deposits known to exist at various points in Venezuelan territory.

The Caroni plant has been under consideration for a number of years. It is planned for construction at a point near the juncture of the Caroni and Orinoco rivers, near San Felix. The stations, with a total capacity of 150,000 kW, were envisaged in earlier plans. Now that the obtaining of foreign steel for Venezuelan industry is becoming increasingly difficult and expensive, the Caroni plan may well be expedited.

New Zealand Reserves

YET another country has indicated that the whole of the water-power reserves will be harnessed within a given, short, and completely foreseeable period. Mr. M. G. Latta, Chief Electrical Engineer to the State Hydro-Electric Department, first indicated in 1950 that the North Island's rivers could only provide enough power for the next ten years' needs. Now he reinforces his warning, and suggests that alternative sources of power should be sought, or that a cable to the South Island, where a much greater power reserve exists, should be contemplated.

The growth of hydro power in the Dominion has been extraordinarily rapid. In 1930 the hydro schemes generated 710 million units a year; in 1948, the annual figure was 2,500 million units; and in 1951 the figure rose to 2,643 million units, a figure somewhat lower than expected, on account of drought restrictions.

Fortunately, the majority of areas of the world's surface have enormous unharnessed water power resources, such as those in the Himalayas and on the Congo. Transmission of power from where it is generated to where it is needed seems to be the most pressing need of the future.

Two Scottish Schemes Inaugurated

TWO of the North of Scotland Hydro-Electric Board's smaller schemes were officially opened at the end of May—Kerry Falls by Mrs. Stirling of Fairburn, and Storrs Loch by Lady Rachel Stuart. The Kerry Falls scheme will serve the Gairloch district of Rossshire, and provides for a plant capacity of 3,000 kW. At the outlet of Loch Bad-an-Sgalaigh a regulating weir has been constructed which is 20 ft. high and 490 ft. long. A pipeline has been laid in the bed of the river Kerry to facilitate the flow of water to an intake weir, about three-quarters of a mile downstream. From this weir a 49 inch diameter pipe takes the water to the generating station.

The Storrs Loch scheme will provide electric power for the Isle of Skye, and utilises two lochs in the northeast of the island. A gravity dam, 251 ft. long and 44 ft. high, has raised the level of Loch Leatham 18 ft. so that this loch and nearby Loch Fada now form one loch, and a pipeline, 2,300 ft. long, conveys the water to a station on the shore, where three 800 kW sets operating on a gross head of 447 ft. will ultimately be installed. The station will operate in conjunction with the Lochalsh station on the mainland, with which it is connected by submarine cable.

Progress in Scotland

THE North of Scotland Hydro-Electric Board's Annual Report for 1951 was published last month and gives an interesting account of the expansion that has taken place. By the end of the year over 280,000 kW of new capacity was available, producing 576 million kWh per annum, while total production, including the output of the prewar Grampian stations at Rannoch and Tummel, reached an annual rate of nearly 900 million kWh, equivalent in terms of coal to about 570,000 tons or well over one week's output of all the Scottish coal pits. When all the schemes now being surveyed, promoted and constructed are in operation, this production will be nearly quadrupled. The accompanying table shows the present position at a glance.

	Total Capacity kW	Estimated Annual Output kWh
In Operation:		
Constructed by the Board	282,585	576,000,000
Transferred to the Board	84,915	297,000,000
Under construction ...	292,000	809,000,000
Promoted but not yet under construction	71,100	232,000,000
In course of promotion ...	155,000	568,000,000
Under survey	212,000	751,000,000
	1,097,600	3,233,000,000

Capital expenditure during 1951 amounted to £11,409,786 bringing the total up to £69,128,378. A substantial volume of work is in hand and the total of borrowing consents already given is £92,855,613. The capital expenditure on distribution was £2,863,011. Unfortunately the fact that the population is scattered over a wide area involves disproportionately high distribution costs, the average cost of connecting a new consumer now being £152.

Putting the Lid on it

ENGINEERS of the Aluminium Company of Canada, Limited, are introducing to North America a new design for the hydro-electric power stations being built at Chute du Diable and Chute-à-la-Savanne in northern Quebec, where the temperature sometimes drops to 40° below zero. Engineers have eliminated the conventional power house around the generators. Instead, the generators will be sunk in a continuing part of the concrete headblock with a detachable cover of aluminium sheet to provide protection from the weather.

Being corrosion resistant, the aluminium roofs will require little or no maintenance or insulation. A gantry crane with enclosed sides which can drop a housing over any individual generator will provide the necessary protection when work is done in inclement weather.

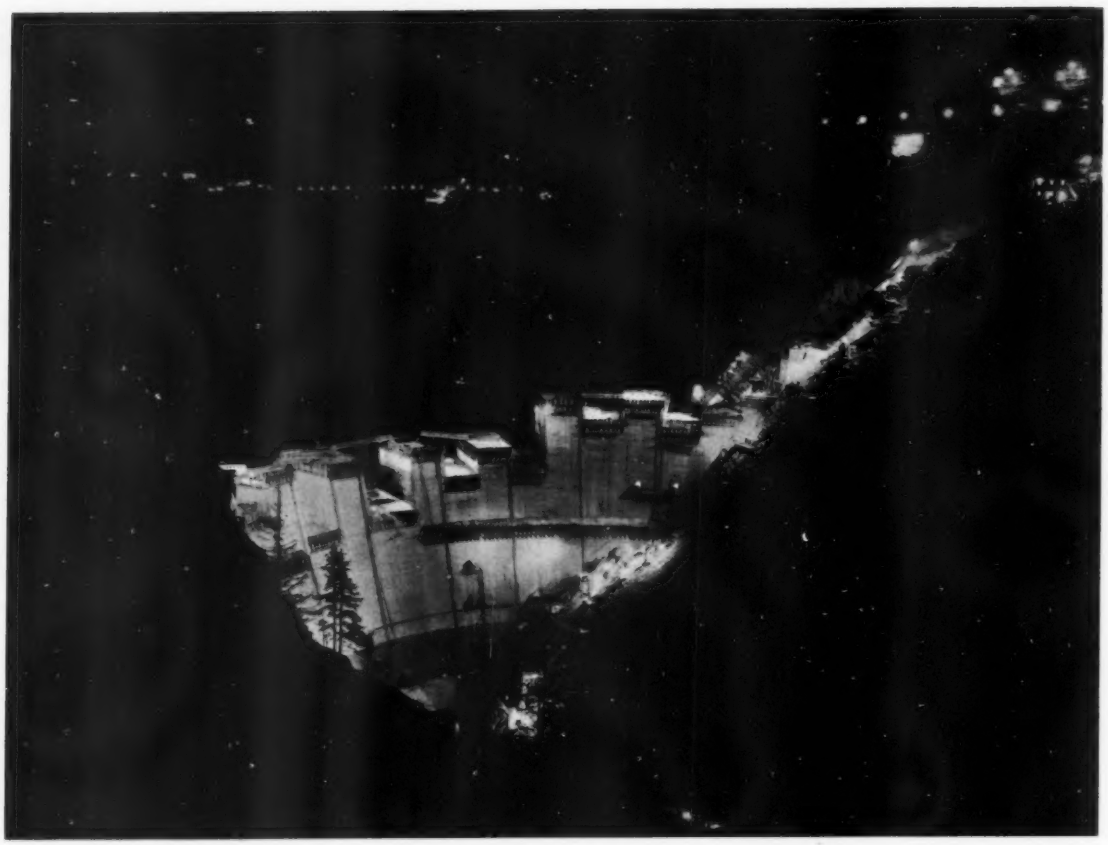


Fig. 1. The Tignes dam at night, September 11, 1951

The Malgovert Tunnel

Dr. Charles Jaeger gives a first hand account of a tunnelling operation that is being accomplished successfully under extraordinarily difficult natural conditions.

THE Tignes dam and the two power stations of Les Brevières at the toe of the dam (230·50 m. head) and Malgovert (head 750 m.) were described in this journal some time ago*. Fig. 2 conveys some idea of this dam, the highest arch dam now under construction in Europe, and shows the state of progress at the end of the summer period of 1951 (October 12). Work started again in April this year. On the occasion of a second visit to the site in the summer of 1951 the work was found to be proceeding rapidly. During the period beginning March 22, 1951, and ending October 27, in 137 working days 302,000 cu. m. of concrete were poured into the dam, making an average of 2,200 cu. m. a day. This is more than the contractor himself expected.

During the winter of 1950/51, the contractor made important modifications whereby his concrete-mixing plant could handle stone of a maximum diameter increased from 150 mm. to 250 mm. Fig. 3 gives an idea of how this concrete looks when being poured at site. The cement content is 250 kg. per cu. m. of concrete; the crushing strength after 28 days is 250 kg. per sq. cm.

The main pressure tunnel (D = 4·55 m. equivalent diameter, 16·38 sq. m. area; Q = 45 cu. m. per sec.; length approximately 147 km.) leads from the Les Brevières power station to the surge tank; thence two

* See Ch. Jaeger: "A Study Tour in the Alps." WATER POWER, May 1951. The Tignes dam is 180 m. high, crest length 425 m. including abutments. Total volume 700,000 cu. m. The Les Brevières power station at the toe of the Tignes dam will be equipped with three 43,800 h.p. reaction turbines.

Fig. 2. The Tignes dam on October 12, 1951

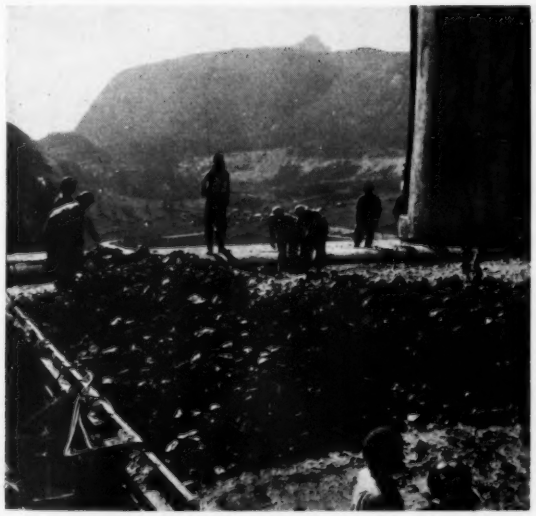


Fig. 3. Concrete with 250 mm. stones being poured into the Tignes dam

pipelines continue to the power house at Malgovert.

These pipelines are very remarkable because each is dimensioned for production of 203,000 h.p. Parts of the pipelines are prestressed with high-tensile steel

Fig. 4. Prestressed pipeline and Y-piece in course of erection (November 21, 1951)

Fig. 5. Interior of Malgovert power house taken during the erection of the four 105,000 h.p. double-overhung Pelton-wheel turbines (November 21, 1951)

Fig. 6. Crushed concrete lining inside adit No. 13. Where the large fissure can be seen the lining has been displaced by an amount up to 5 ft. (December 1948)

Fig. 7. Steel supports in main tunnel distorted under heavy pressure (August 11, 1951)

cables. The principle and technique of these French prestressed pipes is well known[1]. The Malgovert pipes are somewhat different from previous designs

1. *La Houille Blanche*, Vol. 4, No. 3, May 1949, p. 231.

Fig. 8. Horizontal reinforced-concrete beams supporting the footings of the steel frames (November 20, 1951)

Fig. 9. Crushed and sheared reinforced-concrete footing (July 16, 1951)

inasmuch as the cables are not wound in spirals round the pipes but in circular loops, each loop being spliced without apparent joint. Part of one of these pipes and a Y-piece leading from the pipe to the two distribution branches can be seen in Fig. 4. The Y-piece is a sphere, whereby the pressure is balanced[2].

The Malgovert power house is equipped with four double-jet horizontal Pelton wheels, each of 105,000 h.p., and four generators of 80,000 kVA, 428 r.p.m., the gross head being 750 m. Fig. 5 shows the turbines being erected, reputedly the biggest of this type in the world. The output of Les Brevières is expected to be about 150 million kWh per annum, and that of Malgovert as high as 530 million kWh per annum.

The work on the dam and on the power house, including erection of the turbines at Malgovert, is proceeding normally and rapidly. The Tignes reservoir has

2. A similar Y-piece was described in *La Houille Blanche*, May 1949, p. 236.

Fig. 10. Steel frames, concrete reinforcement and timber struts in a difficult tunnel section (November 20, 1951)

been filling during the spring of 1952 in order to run the station of Les Brevières as soon as possible. The major item to be completed is the long Malgovert pressure tunnel, which has been delayed in construction by the many problems to be solved.

Work on the Malgovert tunnel was first started in 1939, on the basis of the 1938 project, but the whole scheme was considerably enlarged (with the addition of the Tignes dam) when Electricité de France took over shortly after the end of the war (1947). Two tunnel sections have been used: a horseshoe section of 16·38 sq. m. in good rock, and a circular section of about 16·25 sq. m. (internal diameter 4·55 m.). Fourteen adits have been driven into the tunnel at various points along its length, mostly accessible by "jeep roads" only, but one is approached by a branch cable way (adit No. 13).

The upstream part of the tunnel (adits Nos. 1 to 12) was in sound rock, and the contractor (L'Enterprise Industrielle, who is responsible also for the construction of Tignes dam and to whom we are much indebted for the illustrations of this article) could take full advantage of the heavy plant he had accumulated along the tunnel in order to speed up its construction. It was soon discovered that, for the downstream part of the tunnel (adits 13, 14 and 16), the rock was of poor quality, including crushed quartzite, decomposed schists and coal seams.

At adit No. 13, when driving the pilot tunnel in the upstream direction, a zone of broken quartzite was encountered, causing fine granular material and water to run into the tunnel at 130 m. from the entrance. Work had to be given up at this opening and another was made at a point further downstream on June 30, 1947. After progressing about 100 m., cutting was begun upstream and downstream to connect back with the theoretical layout of the gallery. At the point 131·70, a fresh inrush of sand and water similar to the previous one occurred, necessitating a fresh change in direction. After soundings had been made it was decided to cut deep into the mountainside directly in line with the new opening. Unfortunately when the work had been

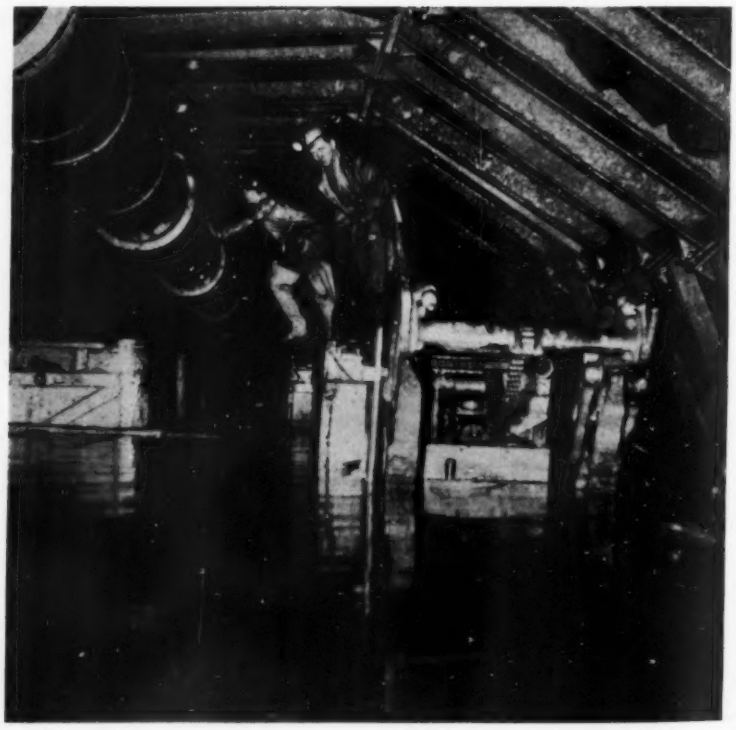


Fig. 11. Flooding of No. 16 adit (December 2, 1950)

Fig. 12. Steel reinforcement for concrete lining (November 20, 1951)

Fig. 13. Steel shuttering in the foreground, with a completed tunnel section in the rear (November 20, 1951)

carried as far as point 239 m., a tentative cutting in the upstream direction met the same difficulty as before after only a few metres.

Many trial bores from the surface made it possible to define the danger zone with some accuracy. It was thus shown that there was no practicable way to avoid having to cut from 50 m. to 60 m. of waterlogged sand from between two strata of coal-bearing rock through which the remainder of the gallery was to extend. This discovery led to the decision to open without delay a further adit No. 12 which, together with No. 13, would adequately delimit the boundaries of the difficult section, and, pending development of a suitable procedure for handling the gallery section between openings 12 and 13 (a distance of about 100 m.), to carry on with the drilling by normal methods from adit No. 12 towards No. 11, and from adit No. 13 towards No. 16.

Attempts were made to stabilise the ground by grouting cement from outside but the results were negative. A specialist firm was then called in to carry out grout-

ings from within the gallery. The chemical formula of the grout used has not been disclosed. It is a gel, probably a silica gel, and the grouting pressure is about 8 atmospheres. The grout is applied behind a concrete retaining wall of 1·50 m. thickness, over about 35 m. length at a time. After grouting, the excavation of the tunnel may proceed with due care.

Fig. 6 shows a crushed concrete lining in adit No. 13, on the bend where this adit joins the main gallery. Owing to poor rock conditions, the adit was lined immediately after the excavation. The gallery is of horseshoe shape.

Suddenly one night the thick concrete lining gave way under the pressure of the rock, being pushed towards the axis of the gallery as much as 1·50 m. The tunnel invert and the railway track were lifted. Some of the heavy timber beams used for urgent reinforcing were crushed and had to be replaced.

From adit No. 13 downwards, rock conditions varied from acceptable to pretty poor. Steel props are in use everywhere. These props despite the heavy sections and the care with which the various prop elements are assembled, in some cases prove inadequate to withstand the pressure of the ground and it is often found necessary to reduce the normal 1·25 m. spacing by one-half or two-thirds. Fig. 7 shows such steel frames in the main tunnel being crushed by the heavy rock pressure. Fig. 8 shows a reinforced-concrete beam supporting the footings of steel frames which hold the tunnel soffit. Fig. 9 shows a concrete beam as above, which has been sheared and crushed and is now being supported by timber struts. Fig. 10 shows in the background a series of steel frames in position. Where the men are standing the base of the steel frames is supported by a concrete abutment. Where the two miner's lamps are hanging on the wall, the tunnel is maintained by a complete concrete ring which is larger in diameter than the future concrete lining and, therefore, will later on be covered by the ordinary lining. In the foreground the reinforcement bars from the tunnel invert can be seen. The heavy horizontal timber struts point to heavy rock pressure, which was at its worst where the concrete ring had to be built in. In Fig. 11, the adit gallery No. 16 was flooded, and 4,500 g.p.m. pumps were being installed.

As may well be imagined, a wide variety of tunnelling methods have been employed during the course of the work. The contractor relied on a high degree of mechanisation of the tunnelling. The tunnel sections are being excavated along their full length before shuttering and concrete lining commence. The concreting plant is similar to that used for Cordeac tunnel (near Grenoble). Dry batches of aggregate and cement are measured into skips which are then driven to the concreting station. Mixing and placing are then carried out in one operation by a compressed-air machine known as "Johnny." After a mixing time of forty to fifty seconds, the mix is shot into the shutter. Fig. 12 shows the reinforcements ready for concrete lining and Fig. 13 refers to the concreting process. In the foreground the steel shutters are seen in position; in the background a tunnel ring is already concreted.

Real difficulties began at adit No. 13 and on the downstream part of the tunnel to adit No. 16, where crushed rock, "squeezing ground" and soft coal were encountered, and water and powdered material (so-called "milonite") formed by the decomposition of schist ran into the tunnel. In this part of the tunnel all known tunnelling methods were used; sometimes the contractor blasted out a bottom heading (about 10 sq. m. cross section), and followed up with a top heading and lateral widening of this excavation. Where necessary, full supporting rings were concreted in immediately, to avoid settlement of the tunnel soffit. In other places, work began with the top heading; this method was found to give unsatisfactory results.

A long period of time had to elapse between the blasting of the tunnel and putting in the concrete lining. Settlement of the tunnel soffit up to 0·30 and 0·80 m. occurred on long stretches of the main gallery and the tunnel soffit had to be realigned before the concreting could commence. It was necessary to wait until the rock settlements ceased before realignment was possible.

The Malgovert tunnel is a most interesting example of a great tunnel being carried through successfully under very difficult conditions.

International Hydraulics Research Meeting

In accord with the plans made at the Bombay meeting of January 1951, the Permanent Committee of the International Association for Hydraulic Research is organising a plenary meeting of the Association at the University of Minnesota in Minneapolis, Minnesota, U.S.A., during the week beginning August 30, 1953. This meeting will be arranged jointly with a meeting of the Hydraulics Division of the American Society of Civil Engineers.

The subjects to be discussed at the meeting are intended to be restricted to the following: (1) Density currents; (2) Air entrainment by flowing water; (3) Waves, beach erosion, and hydromechanics of shore structures; (4) Basic relationships of sediment transportation by flowing water. Papers on the above subjects are now welcomed, and since it is intended that accepted papers be preprinted and distributed before the meeting, receipt of manuscripts at an early date will greatly assist in permitting a most timely distribution of the preprint.

Those who wish to submit papers, who would like to attend the meeting, or who desire any further information about the meeting or about the Association, are invited to communicate with the Association at St. Anthony Falls Hydraulic Laboratory, Minneapolis 14, Minnesota, U.S.A.

Colombia Scheme Nears Completion

The completion of the 50 MW Medellin plant, on the Rio Grande, in Colombia, is now scheduled for the end of this year. The early stages of this project were marked by financial problems, which necessitated first an internal loan of $10 million, then the formation of a new company with a Government guarantee, which raised bonds for $2,800,000 in 1951 and $2,000 in 1952; a further Government loan of $3,200,000, and finally a $2,500,000 (U.S. Dollar) loan from the Export-Import Bank.

This scheme, in which one 25 MW unit was commissioned earlier this year, will be of considerable help in providing power for the expanding industries in the Medellin area.

The International High-Tension Conference, 1952 (C.I.G.R.E.)—I

The 1952 meeting of the C.I.G.R.E. Conference was held in Paris from May 28 to June 7 and was attended by over 1,000 engineers from all parts of the world. In this, the first of three articles, J. H. M. Sykes reviews those parts of the proceedings of the Conference of special interest to hydro-electric engineers.

AT the 1952 C.I.G.R.E. Conference 120 papers were presented. Of these nine dealt specifically with alternator problems, and a number of them were of special interest to those responsible for the design, operation and maintenance of the alternators found in hydro-electric plants.

Alternators

One question which has been raised before, but which still apparently admits of a considerable degree of argument, is that concerning the standardisation of the generating voltage for large machines, "large" in this connection being defined as over 5,000 kVA. In a paper by Professor Giovanni di Vito, of Italy, the author stated that the manufacturer ought to be permitted to choose freely, among a number of standard voltages. that value which he considered best for the particular machine being designed. He considered that there was always a value among the standard voltages for which a machine can be wound without appreciably increasing the cost price, as compared with the price which would be necessary if there was complete freedom of choice of voltage.

The Chairman of the Generator Study Committee of C.I.G.R.E., M. Belfis of Alsthom, commenting on Professor Vito's paper, stated that the Committee considered the standardisation of voltage to be of great importance, and that an international standard of voltages for rotary machines should be deplored; although it was possible that in the case of machines of an output of over 125 MVA the choice of voltage should be left entirely to the manufacturer, at any rate until further experience was gained.

The paper sets out, in detail, difficulties that arise when successive steps in a proposed standard schedule differ from each other by various ratios other than those which the designers would naturally find the most convenient.

It is suggested that the standardisation of voltages might eventually conform with the voltages used on distribution systems, and this would increase the number of generators which could feed directly into the supply network without an intermedite transformer. If this were the case, these machines would be directly subjected to all the surge voltages produced within the network, and consequently the path to further research is opened in the direction of defining the level of resistance to surges of such generating units.

The second group of papers in the Alternator Section dealt with the choice of characteristic factors for rotary machines. The characteristic factors determining the behaviour of a synchronous generator were dealt with in a paper by *M.* O. Hess of Brown Boveri, under the headings of acceleration times, synchronous and transient reactances.

The acceleration time T_a is defined as the time in seconds which a machine takes under its nominal torque to reach its nominal speed from rest, while it may also be defined as the quotient of twice the kinetic energy contained in the rotor at normal speed divided by the normal apparent output of the machine. If the designer of a synchronous machine were guided solely by considerations of cost price he would use a low acceleration time, especially for machines having a moderate angular velocity. On the other hand, a high acceleration time leads to hydraulic stability and has advantages in respect of the possible overspeed reached when the load is suddenly thrown off. Consequently, the majority of designs represent a compromise between these two points of view.

The acceleration time may be reduced by the improvement and strengthening of the means of stabilisation utilised in hydraulic regulation, and also by the artificial increase of auto-regulation of the network on ohmic loads by providing for the regulation of voltage as a function of the frequency. A decrease in acceleration time causes an increase in overspeed and a consequential increase in voltage, a lessening of hydraulic stability, an increase in limits of frequency drift and difficulties in regard to waterhammer, although, on the other hand, there is an easier return to synchronism in case of system disturbance. It is proposed that a family of curves should be established by the Generator Study Committee of C.I.G.R.E., setting out the maximum values of acceleration time which manufacturers would not consider exceeding without an appreciable increase in the price of their machines.

The behaviour of a synchronous machine from the point of view of its reactance is the next aspect of *M.* Hess's paper. The synchronous reactance is difficult to reduce when the machine has an acceleration constant close in value to that of the natural acceleration constant. For hydraulic machines the eventual reduction of acceleration constants could lead at the same time to the possibility of an increase in the value of longitudinal synchronous reactance. Modern voltage regulators are able to cope with the operation of alternators whose capacitative reactance lies between that of the longitudinal reactance and the transverse synchronous reactance. The condition of operation in which long overhead lines have to be connected to the generators is no longer one which necessitates low

values of longitudinal reactance, as values of transverse synchronous reactance varying between 0·6 and 0·7 considerably enlarge the scope of operation under capacitative loads.

Turning to transient reactance, machines are often manufactured with relatively low values of transient reactance owing to the problems of dynamic stability. The minimum value of transient reactance is detected by the value of the instantaneous short circuit, for there are relatively close relationships between the values of the transient and subtransient reactances. A value of 0·2 is regarded as the lowest limit of transient reactance, but for machines having a large number of poles this value is generally considerably exceeded.

Figures given in the review of the generator papers presented for the Study Committee by *M.* Belfis show that for hydraulic machines the following values may be regarded as typical:—

	1,000 to 500 r.p.m.	500 to 250 r.p.m.	250 to 50 r.p.m.
	%	%	%
Synchronous reactance - -	150 to 120	130 to 95	110 to 90
Transient reactance - -	25 to 35	24 to 35	25 to 40

The damping constant of a machine is defined as the damping torque in unit value corresponding to slip equal to unity, this value being calculated by extrapolating linearly the values of damping torque calculated for minor slips, and it is shown that the various methods of construction for alternators lead to widely differing values of damping constant. The possibility of speed regulation being affected by the use of insufficiently damped machines is one which the Study Committee thinks should be discussed among operators of machines of various classes. Among the reasons which have led to the adoption of a high degree of damping is that of the possibility of running under unbalanced conditions, and the desirability of the reduction to a minimum of the voltage surges occurring in the case of single-phase short circuits.

Another view on the inherent characteristics of alternators driven by hydraulic turbines was given in a paper by *M.* R. David, Chief Engineer of *Le Materiel Electrique S.W.* The author of this paper considered that it is possible, by starting with a conception of "inherent output" of a machine of given size (this conception corresponding to an optimum use of active materials), to arrive at an evaluation of natural acceleration constants and of inherent transient reactance of alternators driven by hydraulic turbines. The inherent output proposed by the author was given by the formula

$$P_n = 0{\cdot}0666\,\omega\, dDL$$

where ω is the angular velocity, D the diameter, L the length, and $d = \frac{D}{p}$, where p is the number of poles.

The inherent moment of inertia of a machine of given output is defined as that which a designer decides on if he does not have to meet any special conditions. It is a moment of inertia which has natural dimensions corresponding to a fixed output — the inherent output. *M.* David states that the moment of inertia imposed on a designer is frequently in excess of the inherent moment of inertia defined as above. Attempts have been made in the past to limit the overspeed to 25 to 30 per cent. increase above the normal speed, but there seems today to be a general agreement to relax this rule and to allow higher overspeeds.

A paper from Sweden, by Messrs. T. Stromberg and K. Knudsen of A.S.E.A., dealt with the voltage stability of synchronous machines with or without voltage regulators. They stated that the conditions for voltage stability when a generator is working on an impedance load, are that first when the voltage is manually controlled the excitation and the direct axial field in the rotor must be positive, *i.e.* in the normal direction. If the load is almost capacitative this requirement is fulfilled when the capacitative impedance is greater than the direct axial synchronous reactance.

When the voltage is automatically controlled, the direct axial field in the rotor must again be positive. If the load is almost entirely capacitative this requirement is fulfilled when the capacitative impedance is greater than the quadrature axial synchronous reactance. Speaking of damper windings, the authors stated that, in their opinion, these have very little influence on the stability limits. Saturation has a favourable effect, but it is dangerous to rely on this, because a slight voltage drop may spoil the stable operation and reverse the field. They also reached the conclusion that if the voltage is stable under steady operation it will, in general, also be stable under transient conditions.

Transformers

The Transformer Section included sixteen papers. The principal subject of interest in this field may perhaps be said to be the problems of thermal loading. Mr. E. T. Norris of Ferranti Limited, Chairman of the International Study Committee, in his report on the work of this Committee, mentioned that in recent years much attention has been given to the economic and effective loading of transformers. The fundamental limit of these loads is the maximum temperature the installation will withstand. Thus a great importance attaches to the definition of the hottest spot temperature, and its permissible limiting value for various kinds of insulation and for different durations of load.

The papers showed that the practice regarding both definition of these factors and the loading allowable differ considerably in various countries. A paper on this subject was given by *M.* H. B. Chevalier of A.C.E.C., Belgium. His lengthy disquisition dealt first with a series of definitions, and these may be of interest.

1. *Top oil temperature rise.*—This is defined as the temperature rise of the top layer of oil, situated in the main tank of the transformer, above cooling medium temperature, and is measured by means of a thermometer or a thermocouple.

2. *Mean effective oil temperature rise.* — This is defined as the mean rise above the cooling medium temperature of the volume of oil corresponding to the windings being cooled. This can be measured directly by means of thermocouples in the oil channel situated inside the windings.

3. *Mean winding temperature rise.*—This is the mean winding temperature rise above the cooling medium temperature, and is generally determined by the method of variation of the ohmic resistance of the winding.

4. *Winding gradient.*—This is defined as the temperature gradient existing between the copper of the winding and the adjacent oil.

5. *Hot-spot temperature rise.*—The normal hot point corresponds to a hot zone the temperature of which is above the mean copper temperature.

6. *Time constant.*—The time constant τ expresses the time necessary to reach the final temperature θ_u from an initial temperature θ_i if the initial rate of temperature rise was maintained. Thus

$$\tau = \frac{\theta_u - \theta_i}{\left(\frac{d\theta}{dt}\right)} t = 0$$

The effects of overloads were then dealt with in *M.* Chevalier's paper. He started by saying that the notions concerning ageing are still rather vague and empirical. They result from the variations as a function of "temperature-time" of the tensile resistance of the installation. Other factors, such as mechanical vibrations and electrodynamic shocks, must also be taken into consideration. It has been often accepted that for a hot-spot temperature maintained at 95°C. the transformer with protected oil (by the use of a conservator or with a neutral atmosphere) has a normal life duration. This definition has been adopted by A.S.A. and B.E.A.M.A. regulations for the making of overloading rules. The normal rate of ageing relates to ageing under normal continuous load and normal overload. A normal cyclic load is defined as that which at the end of a cycle has caused a normal rate of ageing, i.e. equivalent to that which would result from a continuous normal load. The daily cyclic operation under the British B.E.A.M.A. rules is defined as a daily operation consisting of eight hours at a 105°C. (overload) followed by sixteen hours at 80°C. (reduced load). British experience indicates that this daily cycle ensures a normal life of 25 years.

Turning to abnormal or emergency overload, the author stated that it is necessary to check whether the exceptional emergency overloads are permissible by factors not connected with the thermal behaviour of the windings, such as the possibility of oil expansion or internal pressure limitations, bushing defects, voltage regulator problems, the effect of the overload on internal connections and joints and external connections, and finally, overload conditions that may arise due to the presence of excess current in cables, circuit breakers, instrument transformers and the like.

As an instance of the effect of abnormal overloads the author quoted a case where if a normal ageing rate of 5 per cent. per year is taken, a single abnormal overload in the year, corresponding to a 1 per cent. ageing, brings to 6 per cent. the rate of annual ageing and reduces the vitality to 36 per cent. in a period of 16·6 years instead of the normal 20 years. The probable life of the transformer is, therefore, reduced in the ratio of 20 to 16·6.

The author suggested that a transformer whose theoretical vitality has been exhausted after two or three years of service can be rejuvenated fairly quickly by replacing the windings, the cost of which rarely exceeds 35 per cent. of the cost of the complete unit.

Thermal Image

In recent years a great deal of attention has been focused on devices used for assisting in loading transformers in such a way that their useful life may be utilised in the best possible fashion. Amongst the devices that are of the greatest assistance in this direction is the thermal image. Much has been heard of this device in recent years, but it still appears that there is some divergence of viewpoint as to an exact definition of its construction and functions. The British, Swiss and American definitions, as given by *M.* Chevalier, are as follows:—

British definition

The thermal image is a device used for the reproduction of thermal conditions in a winding of a transformer when the placing of temperature-measuring instruments is not desirable or practicable. For oil-immersed transformers the thermal image is generally made up of an element sensitive to heat inserted in a heating element tube in the top oil of the transformer and fed by a current transformer.

Swiss definition

The thermal image is an object of suitable size situated in the top oil layers and heated by a current proportional to the current of the transformer. The temperature of this object corresponds to the temperature of the hottest point if certain conditions are fulfilled.

American definition

The transformer thermal *relay* is a device which shows that time-temperature limits in the windings have been reached. It is calibrated for a given transformer and automatically takes into account the hot-spot temperature, the ambient temperature and the preceding conditions of loading.

The paper by *M.* Chevalier also gave a summary showing the suggestions put forward by Britain, U.S.A. and Switzerland, together with certain additional information from Holland and Italy, on thermal questions and the variation between transformer practice in regard to thermal loading in the various countries. He concluded by stating that it is urgent to agree on standard notations for the designation of each of the values used in this aspect of transformer operation, and a guide for normal overloads, with an international standing, should be promulgated.

Surge Testing of Transformers

Reverting to the report of the work of the International Study Committee on Transformers, Mr. Norris said that the general principles of the surge testing of transformers are now well established, but there are many detailed problems to be solved before its practical application, on a commercial and industrial basis, could be regarded as entirely satisfactorily achieved. These problems chiefly concern the means of detecting partial failure of insulation during test, and the location of this failure in the winding.

Papers bearing on this subject were produced by Mr. E. L. White of the Electrical Research Association, Great Britain, by *M.* F. Beldi of Brown Boveri, Mr. P. G. Provoost of the KEMA laboratories in Holland, *M.* A. Pichon of Alsthom, Mr. E. Stenkvist of Sweden, and *M.* R. Langlois-Berthelot of France.

The paper by Mr. White dealt with an experimental investigation of surge-voltage distribution in open-circuited sections of a transformer winding, as occasioned by voltage-regulating tappings. He stated that there was no increase in the maximum voltage between winding and earth, due to the presence of

open-circuited sections, and further, voltages across discs in the open-circuited sections are not higher than across certain of the same group of discs in the case of the full winding.

M. Beldi stated that the present-day measuring technique does not yet allow the operators to draw definite conclusions from tests on transformers with chopped waves. Transformers should be tested, therefore, in the first place only with full waves, although with increased experience, the electro-acoustic method may alter this position. This method consists of the immersion of a pressure-sensitive device in the oil of the transformer, and the result of its operation is displayed on a cathode-ray tube. He also stated that neutral current analysis permits of the distinguishing of winding failures proper or partial discharges, *i.e.* discharges at low current, which do not deteriorate the insulation. He is convinced that the present state of the art is such that there can no longer be any doubt as to whether or not an impulse-tested transformer should remain in service. As long as the transformer is not subjected to a large number of impulses during tests, there is no risk of small discharges leading to a deterioration of the insulation.

A point made in the paper by *M.* Provoost was that the impulse testing of transformers had to be carried out with the low-voltage winding terminated by means of a resistance of suitable value, and that this voltage should not exceed 50 to 70 per cent. of the test voltage for these windings. He also stated that the detection of insulation failures during full-wave testing has nowadays been so greatly improved that objections to this kind of test are no longer valid.

A somewhat different view on impulse testing was held by *M.* Pichon, as expressed in his paper on the surge resistance of transformers with concentric windings. He stated that all the overvoltages which can occur in a normal disc winding of a transformer subject to surge voltages cannot be determined by calculation with a sufficient degree of accuracy. Surge tests enabled an estimation to be made as to whether a transformer conforms to a given guarantee, but they do not give any indication of the safety factor.

Among the conclusions he reached on the general subject of transformer-winding design were that a normal arrangement of windings without exaggerated over-insulation can be used for medium voltages, but for high voltages it is advisable to adopt simple shields by which overvoltages are reduced without affecting the normal construction, while for very high voltages non-resonating windings or multi-concentric high-voltage windings should be adopted.

In the paper by Mr. E. Stenkvist of Sweden, the author points out that two methods of connection are available for surge testing, namely the line-current connection and the neutral-current connection. He stated that both are equally suitable but only the first mentioned is theoretically or practically suitable for location of faults from direct readings on the oscillograms. The earthing or short circuiting of windings not under test is a subject which is frequently discussed when impulse testing is considered. Mr. Stenkvist took the view that on large transformers all windings not under test should be short circuited and earthed, but for smaller units it is necessary to leave them open, or cause them to be resistively loaded. He confirmed the conclusions of previous authors that with the use of chopped waves no method of fault indication, at least for the higher voltages, has so far been found.

Fatigue of Insulation

The paper by *M.* Langlois-Berthelot applied, in essence, not only to transformers but to many other types of high-voltage apparatus. It dealt with the fatigue of insulation and the obtaining of knowledge of the processes involved in the measurement of the ionisation phenomena. Investigation of ionisation under impulse conditions is the subject of research which may lead to a considerably greater ability to detect incipient faults before the transformer is put into service. He reached the conclusion that the interval of voltage between breakdown and safe ionisation is narrow, while there is a wide voltage interval between incipient and injurious ionisation.

(To be continued)

Pakistan's Need for Power

At the monthly meeting of the BEAMA Export Panel last month, His Excellency the High Commissioner for Pakistan, Mr. M. A. H. Ispahani, stressed the need for developing that country's hydro-electric power resources.

" Pakistan is short of coal and her output of oil is also low," said Mr. Ispahani, " but she has extensive water-power resources. It is estimated that her power potential from this source is between 5 and 6 million kW." In the course of his remarks Mr. Ispahani said that while an overall power development plan had been under preparation, work has been in progress for increasing the capacity of the existing power stations and setting up new ones, both hydro-electric and thermal. When the Rasul project comes into commission in the Punjab this year, the output of hydro-electric power will be raised to 42,000 kW as against 10,000 kW last year. Next year the Darjai hydro-electric project in the North West Frontier Province will add another 15,000 kW. Within the next 5 to 6 years, it is hoped to harness about 300,000 kW.

In East Pakistan the Karnafuli hydro-electric and flood control project is expected to generate about 120,000 kW. The hydro-electric station to be constructed at Silchari on the Karnafuli river is estimated to cost about £15 million.

The Central Engineering Authority set up by the Pakistan Government on July 1, 1948, is responsible for co-ordinating all engineering activity in Pakistan. In the realm of power development, both thermal and hydro-electric, this Authority is charged with the responsibility of scrutinising, co-ordinating, and even initiating schemes for the control, regulations and utilisation of the water resources of the country. The Central Engineering Authority is assisted by Messrs. Merz Rendel Vatten (Pakistan), a combine of three firms—two British and one Swedish—of consulting engineers of international repute.

Among the factors which are likely to influence the placing of orders for this type of machinery the most important, of course, will be delivery and price. Another important consideration is whether the country supplying the equipment provides adequate technical assistance, including training facilities for Pakistani engineers and technicians.

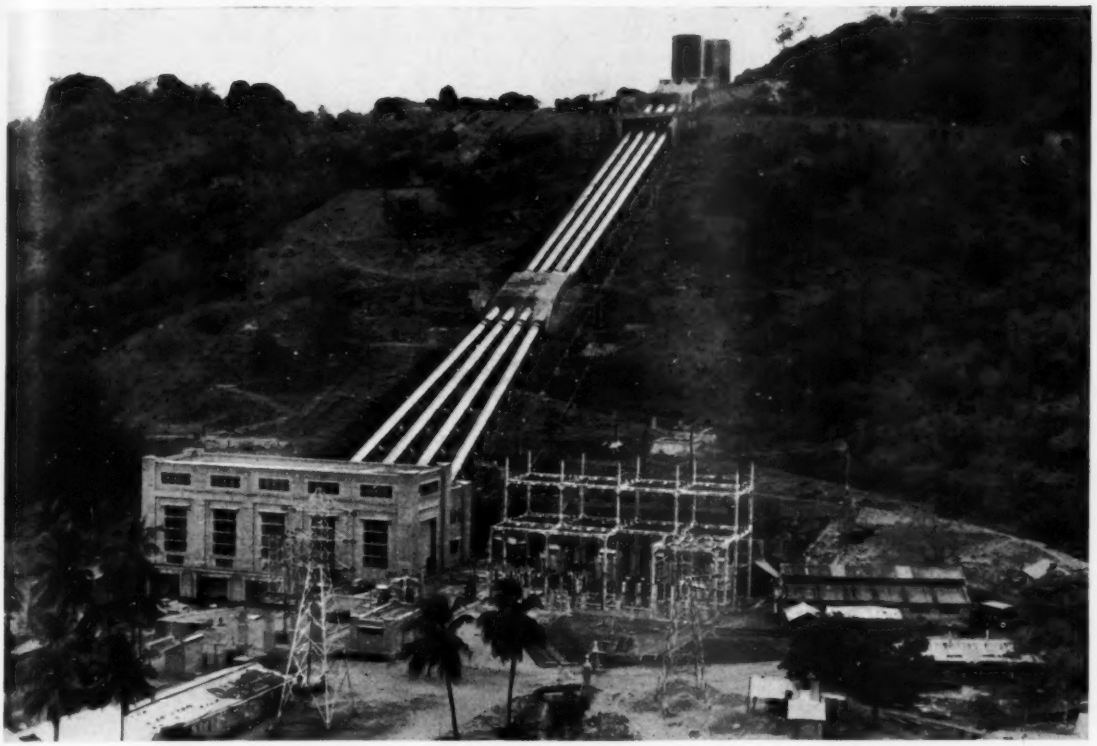


Fig. 1. Papanasam power house showing penstocks and surge towers

The Papanasam Scheme

Particulars are given of a hydro-power scheme in Southern Madras which is combined with an irrigation works and a thermal power plant.

By R. DORAI RAJAN

AMONG the three major hydro-electric schemes now constituting the Southern Madras Electricity Grid, the Papanasam hydro-thermal scheme occupies an important place. Although first investigated in 1926, in connection with several of the larger water-power resources in the Madras State, it was really the stimulus given by the Pykara hydro-electric development that made the Papanasam scheme possible 12 years later. After detailed investigation, the scheme was finally sanctioned in 1938 and included the extension of electrical amenities to the districts of Tinnevelly, Ramnud and Madura at the southern end of the State. A favourable feature which materialised after the scheme was projected was the temporary supply of 3,000 kW to Travancore, to meet the important wartime aluminium manufacturing load and other agricultural and industrial activities, until this power could be supplied by the extensions to the Pallivasal hydro-electric development.

The site of the project is the picturesque Papanasam falls on the Thambraparni river in the Tinnevelly District, Madras State. The catchment area of 57 square miles consists of thickly wooded forests with a rainfall of about 60 in. per annum at the falls, rising progressively to around 200 in. in the higher reaches. There is no suitable site for a storage dam except six miles above the falls. An ultimate capacity of 5,500 million cu. ft. was decided for a dam at this site, as the cost of a greater degree of regulation rose disproportionately, although there were no technical difficulties. Working tables based on the available rainfall and river-flow records showed that during the driest succession of years ordinarily to be expected, and allowing for the full present irrigation supplies, this dam capacity will provide a continuous regulated flow of 360 cusecs for power development.

The scheme is designed as a hydro-thermal development providing for 68 per cent. of the energy to be

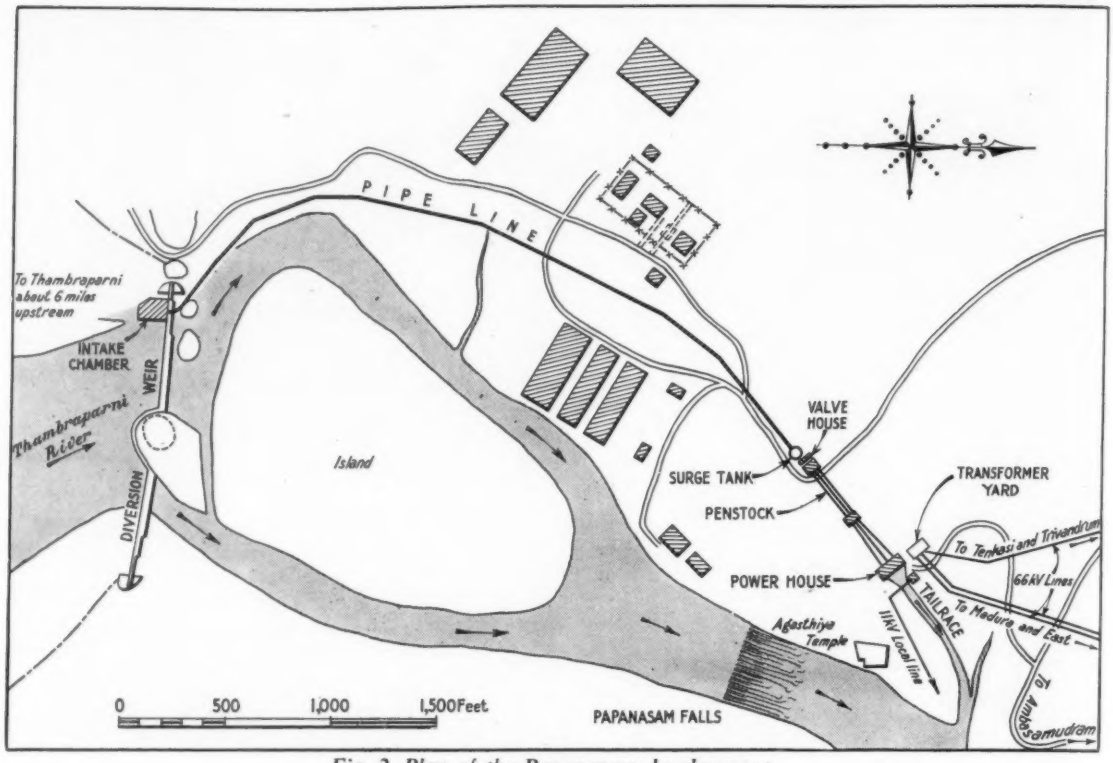


Fig. 2. Plan of the Papanasam development

Fig. 3. Papanasam storage dam on the Thambraparni river impounding 5,500 million cu. ft. of water

generated by hydro power, this being as much as the economics of the site permitted, and for the rest to be generated thermally, this proportion being considered to give the most economical results. The scheme has been developed in three stages (1) hydro-electric development to the extent of the flow continuously available in the river, (2) additional hydro equipment to utilise the water available in good rainfall years, and (3) a steam station to make up deficiencies in years of subnormal rainfall. The first stage, delayed by the war, was completed in 1944. The second and third stages are now nearing completion.

The Thambraparni river drops about 300 ft. over the Papanasam falls, and as a practicable site nearer the falls was not obtainable a diversion weir has been constructed about three-quarters of a mile upstream.

The storage dam, 800 ft. long, is 170 ft. above the level of the river bed and over 200 ft. above the foundations. Pressure grouting to seal fissures in the underlying rock was carried down to 60 ft. below this level. Two discharge pipes of 8 ft. 6 in. diameter are built in the dam, one of which is sufficient to carry the maximum irrigation requirements. They are fitted with the usual screens and intake sluices and regulating valves and pass under the site of a power station at the foot of the dam; this station will constitute the fourth stage of the project and will utilise the flood waters that in the meantime will necessarily pass over the spillways. This station has been planned to accommodate two Kaplan units of 4,500 kW each and the existing works have been made to be readily adaptable to this requirement. The spillway, which is cut in the rock on the right bank, has its sill 18 ft. below the full reservoir level and is designed to discharge a maximum of 90,000 cusecs. In the first stage it was left open but it has now been fitted with six gates 18 ft. high and 52 ft. long, so raising the storage capacity from 4,400 million cu. ft. to 5,500 million cu. ft.

The dam, which is a solid gravity-type structure, is built of random rubble masonry in cement mortar with coursed facing. The structure contains nearly five million cu. ft. of masonry and concrete. Including pipes and controls but without the spillway gates the total cost was Rs. 44·4 lakhs. Allowing for the cost of the gates, this works out to about Rs. 880 per million cu. ft. of storage.

The water thus stored in the Thambraparni reservoir is subject to regulation and is joined by two natural streams before it reaches the diversion weir above the falls. From this weir the combined flow is carried about a mile downstream in two low-pressure pipes 9 ft. in diameter, to the valve house above the power station. This structure consists essentially of an overflow weir, 1,350 ft. long, extending along the full width of the river with an intake

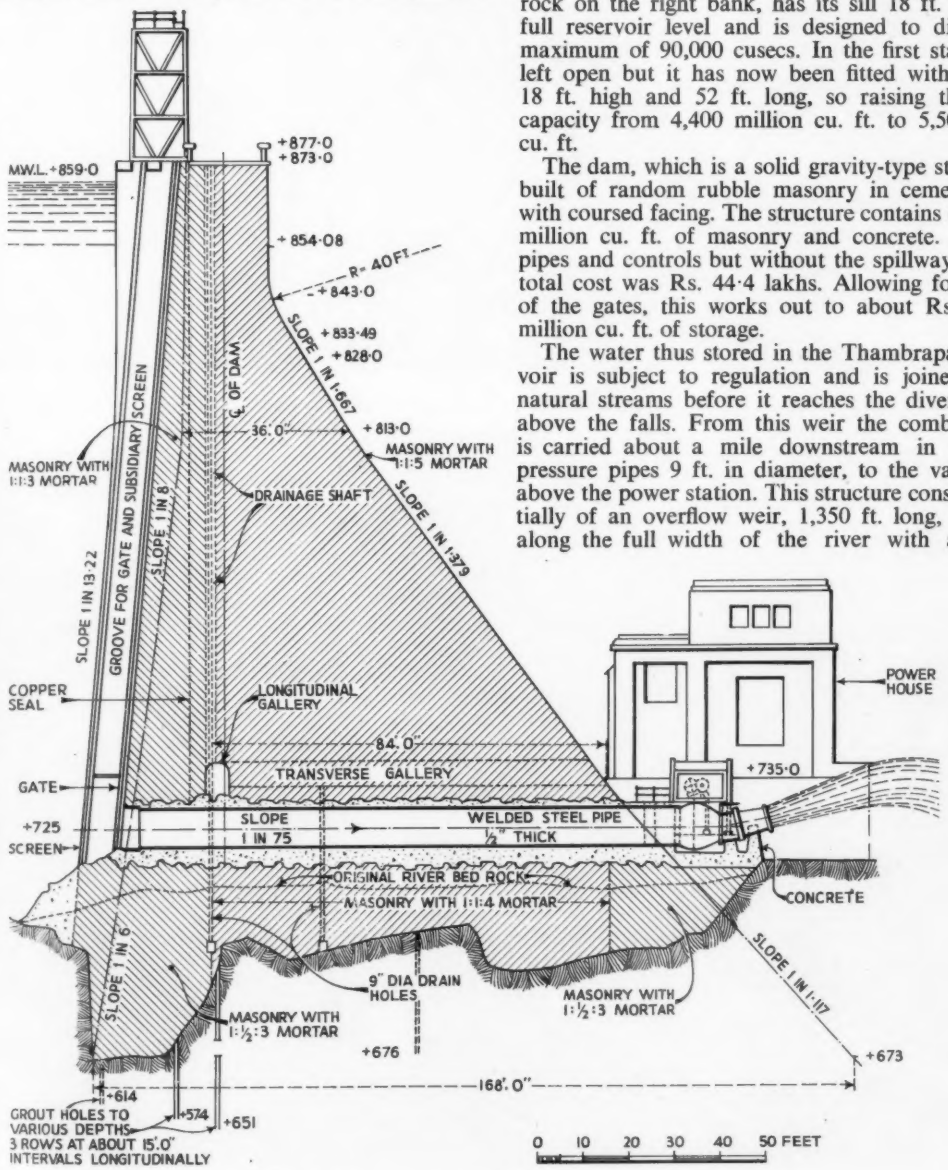


Fig. 4. Cross section of the Thambraparni dam

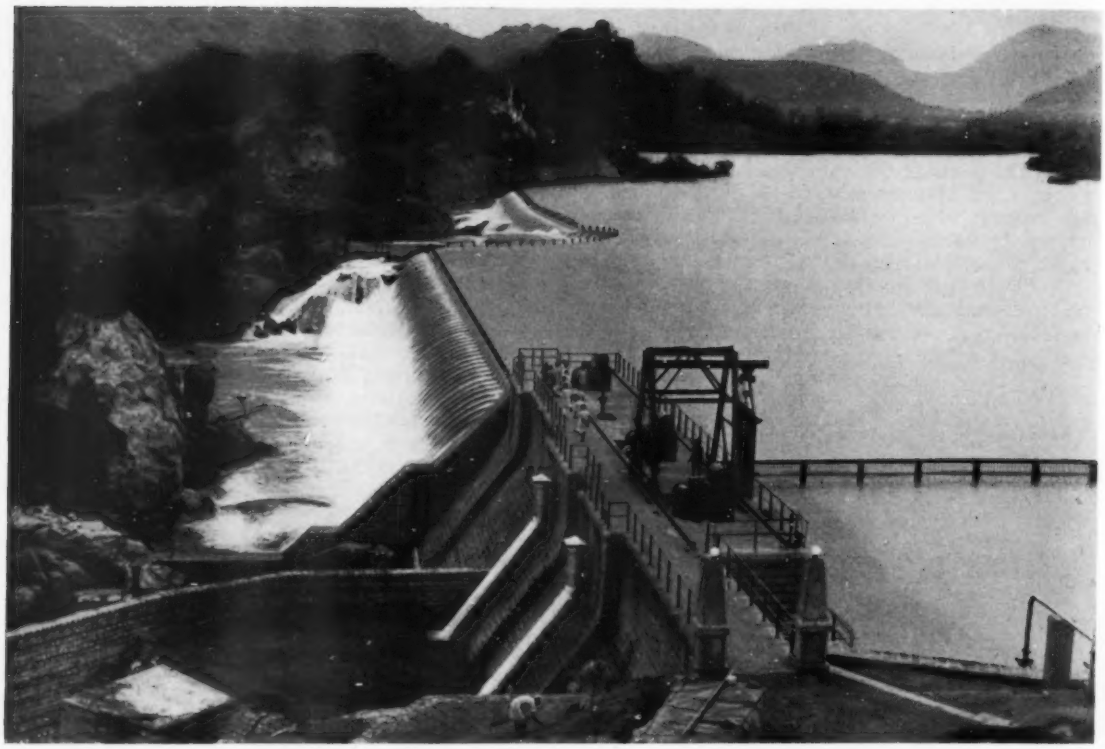


Fig. 5. Papanasam weir, six miles downstream from the storage dam, diverting the flow to the power station

Fig. 6. The twin 9 ft. diameter pipeline taking off from the diversion weir to the penstock head

chamber discharging the pipes at the left bank. The crest is about 35 ft. above the river-bed level and the weir is designed for a maximum flood discharge of 120,000 cusecs. Owing to the nature of the rock, which was deeply fissured and broken, the foundation problems at this site were more difficult than for the dam and the various sections had to be dealt with in different ways. The weir incorporates a rocky promontory in the middle of the river and generally follows the highest sound foundation line. The promontory projects about 60 ft. above the present overflow level.

Although the river has always been remarkably free from silt, even in time of flood, the intake was designed to combat any difficulty likely to arise in future. To this end a stilling chamber has been constructed, protected by a subsidiary weir 10 ft. in height, which permits only top water to enter. This chamber wall is surmounted by a fixed screen to exclude floating debris. Owing to the facts that large tracts of forest were felled in the catchment area to meet the heavy demands for firewood during the war, and that portions of these tracts were cultivated, a considerable quantity of silt has found its way into the river. But this quantity should decrease in course of time as steps are taken to avoid erosion of the top soil.

The capacity of the forebay at spillway level is 28 million cu. ft. which provides one day's effective storage for one machine at full load. Two 9 ft. diameter low-pressure steel pipes fitted with cut-off gates and protecting screens conduct the water for power requirements. These pipes are 3,586 ft. long and are laid with a uniform gradient of 1 in 300, the bends, which are seven in number, being anchored by heavy concrete blocks. They are supported intermediately at 28 ft. intervals on roller bearings to permit movement due to expansion and contraction, and there is an expansion joint for each pipe immediately downstream of each anchor. The pipes were fabricated at site from $\frac{3}{8}$ and $\frac{7}{16}$ in. Tata steel plates and are of welded and riveted construction. The water

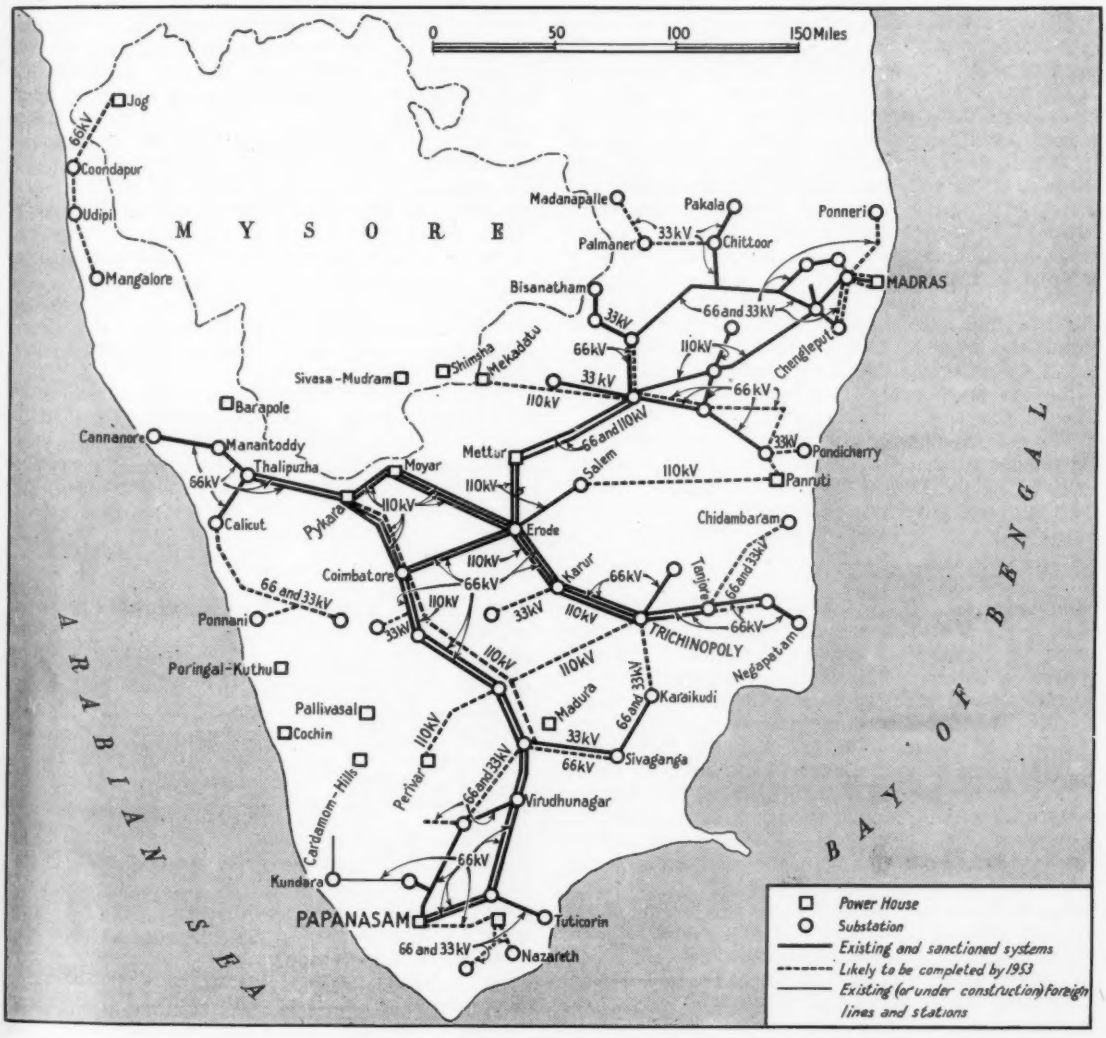


Fig. 7. Map of the Madras Grid South

velocity in the pipes at full flow is 11 ft. per second.

At the downstream end of the low-pressure pipes, and between them and the head of the penstock, are the two differential surge towers. They consist of two vertical risers 9 ft. in diameter and 61 ft. in height and are surmounted by two tanks 25 ft. in diameter, water being admitted from one to the other through five ports 1½ ft. by 2 ft. each. They are designed to take care of the maximum surges that can be expected due to load fluctuations. On the downstream side of the surge towers manifolds are situated to divide the 9 ft. diameter outlet into three offtakes in the first stage, and four in the second stage, each being connected to a corresponding penstock. The second surge tower is located some distance to the rear of the first for convenience of space.

The gross head of the plant is 330 ft. and each penstock is 1,288 ft. long and anchored about midway. They are of riveted steel construction, 69 in. internal diameter and were fabricated at site from Tata plates varying in thickness from $\frac{5}{8}$ to $\frac{3}{4}$ in. They are supported at 20 ft. intervals and expansion joints are provided below the middle and top anchors.

These penstocks were originally designed to be of high-tensile steel of shop-welded manufacture and were ordered from Poland just before the outbreak of the war. As this country was overrun by the Germans, it was not possible to obtain delivery, and riveted pipes had to be substituted to suit plates of local manufacture. Butterfly valves are provided at the head of the penstocks between the top anchor and the surge towers, and also, of course, vacuum relief valves. The former can be either closed by remote control from the power house when the velocity in the pipe exceeds a predetermined limit and can also be operated by hand. These valves, the surge tanks and manifold were supplied by Boving and Co. Ltd. Below the terminal anchors there are high-pressure cutoff valves of the cylindrical balanced type, fitted with automatic controls, supplied by the English Electric Co. Ltd.

The generating plant consists of one vertical Francis turbine for each penstock, designed and manufactured by the English Electric Co. Ltd. and fitted with the usual governing gear and relief valves. Each machine has a designed output of 9,850 h.p. at a speed of 600 r.p.m. They are so constructed that the runners can be dismantled and withdrawn along a horizontal passage without disturbing the generator assembly above.

The generators are of B.T.H. design and manufacture and are direct coupled to the turbines. They are of 5,250 kVA capacity and generate at the standard 11,000 V, 3 phase, 50 cycles.

Equipment for synchronising with Travancore is provided at Papanasam and with Pykara at Madura. The main supplies for Travancore and Madura are stepped up to 66 kV through three transformers of 7,250 kVA capacity each.

All indoor and outdoor switchgear and electrical equipment with the exception of the 2,000 kVA transformers are of B.T.H. manufacture.

The power-house building is a steel-framed structure with walls of local stone, and roof and floors of reinforced concrete. The control panels are situated in a gallery overlooking the machine hall.

The transmission system was constructed by Callender's Cable & Construction Co. Ltd.

This hydro-electric development will be of great benefit to the existing irrigation system of the Thambraparni river, as it will enable water which formerly ran to waste during floods to be stored and utilised during dry periods, when there would otherwise be a serious shortage.

The third stage of power development consists of the construction of a thermal station near Madura. This plant will prevent recurrences of power shortage when the monsoon fails the hydro-electric areas. The first 4,000 kW turbo-generating unit of this plant has already been put into commission and a further 10,000 kW unit is in course of erection. Burn & Co. Ltd. of Calcutta were responsible for both these sets, the boilers being supplied by Babcock & Wilcox Ltd. The estimated cost of the thermal station is Rs. 131·60 lakhs.

The scheme was designed under the direction of Sir Henry Howard, then Chief Engineer for Electricity, who had earned international fame in hydro-electric development. Mr. G. Sundaram, the present Chief Engineer for Electricity, who succeeded Sir Henry Howard, is ably maintaining the high standard set up by his predecessor.

Manufacture of Hydro-Electric Plant in Scotland. During the course of a press visit to the Scotstoun works of Harland & Wolff Limited, Mr. T. Lawrie, general manager of the North of Scotland Hydro-Electric Board, referred to the fact that the manufacture of hydro-electric plant was a relatively new industry in Scotland. The first step had been taken in 1945 when he (Mr. Lawrie) had been sent at the behest of Sir Edward MacColl to ask Sir George Nelson, chairman of the English Electric Co. Ltd., whether it would be possible for such a development to take place. Following upon this visit arrangements were made by which Harland & Wolff manufactured water turbines and generators to the design of the English Electric Company and now contracts were on hand not only for Scotland but also for such widely dispersed countries as India, Portugal, Spain, Australia, Tasmania, South Africa and Egypt. The works have recently completed one of the largest turbine wheels manufactured in Britain, this being the 56,000 h.p. set intended for the Cluchan station of the Glen Shira scheme in Argyll.

Rip-Bits Limited. A number of leaflets, enclosed in decorative folders, describes the various specialities manufactured by this firm: Rip-bits, P.M. bits and rods, Riploy tungsten-carbide tipped bits, servicing plants, pocket pressure gauge, grinding machines, pneumatic picks and digger steels, rotary driller rods, rivet snaps, and pneumatic chisels.

Oil Dynamic and Hydraulic Machinery. A booklet received from Alessandro Calzoni s.p.a. of Bologna, Italy, describes the construction, functions and simplicity of the Calzoni oil-dynamic equipment as applied to their water-wheel governing gear and for operating heavy discharge gates, regulating weirs, butterfly valves, sliding sluices, jet dispersers and other purposes associated with hydro-electric power schemes. Views and brief descriptions are given of a large number of installations.

Water Power in the Faroes

A brief account of a plant now being constructed on the river Fossa, on the island of Strömö, to serve the islands of Strömö, Östero and Vaagö

THE remote community existing on the Faroe Islands, in the Atlantic Ocean, some 250 miles north of the most northerly point of Scotland, comprises over 3,000 people, the capital being Thorshavn, situated on the island of Strömö. This town has been supplied with electrical energy from a diesel plant up to the present time, but a hydro-electric project is now under construction. This has been financed as to 4 million kroner by the Faroese Inter-Communal Electricity Company, S.E.V., as to 3 million kroner by Marshall Aid, and to the remaining 7 million kroner by a loan from the Danish Government who administer the Faroe Islands. About half the 14 million Danish kroner, which the plant will cost, is to be used for the buildings and civil work, and the remaining half for the machines and electrical equipment, including cables. The scheme is shown in outline in Fig. 2.

The plant is situated on the river Fossa, which runs from the Vatnid lake to the Vestmanhavn fiord, on the west side of the island of Strömö. The lake lies at an elevation of 239 m. and a pillar dam, with 5 m. spacing between each pillar and with reinforced-concrete slabs between, has been placed at an elevation of 251 m. at a site some 600 m. south of the lake. The dam is 165 m. long and 15 m. in height. Below this dam the river widens and takes in a number of tributaries, the most important of which is the Bjarnadals river and, some 250 m. south of the point where this river joins the Fossa, a further dam has been built at a height of 224 m. above sea level. This is known as the Lomundoyrar dam, and is 155 m. long and 11 m. high. It is constructed in the same fashion as the Vatnid dam.

The storage capacity of the Vatnid dam is 4 million cubic metres, and that of the Lomundoyrar dam 0·7 million cubic metres. From this point water is taken

Fig. 1. A portion of the Faroes, showing the three islands to be served by the Strömö plant

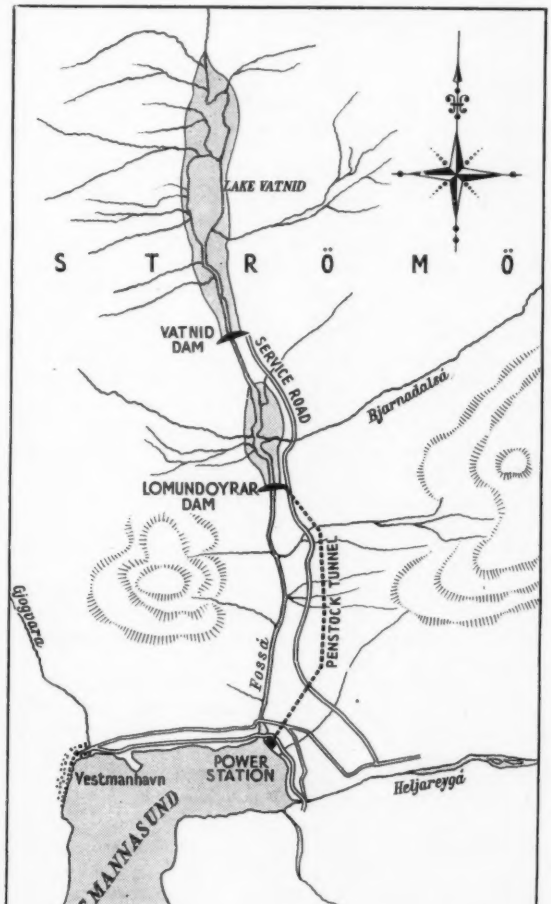


Fig. 2. General plan of the river Fossa development utilising the waters of lake Vatnid

through a hill on the east side of the north-south course of the Fossa river, through a tunnel, of a total length of 1,200 m. and having a cross-section of 2 × 2·3 m. This tunnel is situated at an average depth of 20 m. below the surface of the hill. From a point 600 m. north-east of the power station, which is situated at sea level, a steel pipeline, of a diameter of 0·7 m., carries the water to the turbine.

The power station provides first for the installation of a single unit of 3,000 h.p. which, it is estimated, will supply the whole of the demand on the islands for the first five to ten years. An additional unit can be installed with an additional pipeline, the tunnel being sufficient to carry the water needed for both units. The reinforced-concrete building, at sea level, will contain the turbine and generator, which have not yet been installed, and is situated on the eastern side of the outlet of the river Fossa in the Vestmanafjord.

The energy will be distributed at 20 kV by overhead lines to all the villages on Strömö, and also to the two adjacent islands of Ostero and Vaago, which, together with Strömö, house some 60 per cent. of the total population. Aerial cables across the Sundene, between Ostero and Strömö, and the Vestmanna Sund, between Strömö and Vaago, will carry the current across the narrow sea gaps between the hills. The main output of the plant is likely to be required in the neighbourhood of Thorshavn, the capital, and a main transmission line will pass between those two points through the village of Kollefjord.

Among the civil-engineering aspects of the constructional work was the provision of an access road along the approximate route of the tunnel and beyond it to the Vatnid dam. This was commenced in 1951, and the work also involved the provision of living quarters for the civil-engineering staff. It is hoped that all work on the project will be completed during the autumn of 1953.

The design of the machines of the electrical installation has been in the hands of P.A. Pedersen, of Copenhagen, and tenders are being issued for the actual manufacturing work. The civil-engineering work has been in the hands of Hojgaard and Schultz A/S, Copenhagen, Skaanska Cementgjuteriet, Malmo, together with C. J. Jensen, Copenhagen, and Lamhuage and Waagstein, Thorshavn.

Hydro-Electric Development in Mysore

Mysore, which was the first state in India to generate hydro-electric power of any magnitude, is now on the verge of undertaking large-scale development of its water-power resources with three more hydro-electric projects.

The Cauvery Valley power scheme, popularly known as the Sivasamudram power development, named after the well-known falls bearing the same name, dates back to 1898. The generating capacity of 60,000 h.p. has now reached its ultimate potential. The Shimsha hydro-electric project was the second to be commissioned, in 1940, with an installed capacity of 23,000 h.p. The third was the much larger scheme known as the Jog hydro-electric project with an initial capacity in 1948 of 48,000 kW. In order to meet the increasing demand for power the second stage of this scheme, now nearing completion, will bring its total capacity to 120,000 kW. The total revenue to the State from all these three schemes is over Rs. 1½ crores, and Mysore ranks fourth in India with Bombay, Bengal and Madras leading.

Surveys to exploit the power potential of the Cauvery river and Sharavathi river valleys for increasing the power production have been completed, and plans are now ready for starting the Honnemaradu scheme, the largest single hydro-electric project in India, which is expected to generate a maximum of 400,000 kW. This project has been submitted to the Indian Planning Commission for inclusion in its Five-Year Plan, and the cost is estimated to be Rs. 20 crores.

The scheme envisages a reservoir at Honnemaradu, about five miles up the Sharavathi river from the Jog power station, situated in a narrow valley. A dam constructed to a height of 165 ft. would impound over 10,000 million cu. ft. of water. The storage from this reservoir to the extent required by the Jog station will be diverted into the existing power channel by a dam at Karegal constructed for the purpose. The remaining water will be led either by a tunnel or an open channel into the Takkale valley, across which another dam is proposed to be built to store the monsoon flow and also to serve as a balancing reservoir to the Honnemaradu power station. The water from the balancing reservoir will be led by an open channel or low-pressure pipe to a forebay constructed on the top of a hill whence penstocks will lead the water to the turbines about 1,400 ft. below. The power plant will be installed on the left bank of the river. The power generated will be utilised in the development of electro-metallurgical and electro-chemical industries.

The second is the Mekadatu project which is estimated to cost Rs. 5 crores. The power station is to be located on the Salem-Mysore border. According to the agreement of 1924 on sharing the Cauvery waters between Madras and Mysore States, the right of generating power on the upper reaches of the river were conceded to Mysore which will sell bulk power to Madras.

The scheme envisages the construction of a reservoir above the Mekadatu Falls to augment and regulate the supply of water to the power station. The dam is to be constructed in stages up to a height of 150 ft. and capable of impounding about 15,000 million cu. ft. The first stage of the project contemplates development of about 15,000 kW from a head of 200 ft., and the bulk of the power will be sold to Madras Government for use in the Salem district.

Lastly, it is proposed to increase the generating capacity of the Shimsha power station by diverting more water from the Cauvery river and to construct another reservoir higher up on the Shimsha river, yielding an extra 28,000 kW. When all these power schemes are completed the pioneer Sivasamundram plant will become a seasonal station.

The capital cost of generating one kilowatt of power at Honnemaradu will only be Rs. 500 whereas at Mekadatu it works out at over Rs. 2,000 and at Shimsha about Rs. 1,000.

Abridged List of Products. Holman Bros. Limited have issued catalogue No. G/2007/52 which illustrates and describes a selection of their products suitable for mining work and civil engineering contracts.

The Central Valley Project—II

Stephen H. Poe, of the United States Bureau of Reclamation, gives an outline of this huge multiple-purpose project. The Central Valley embraces 18,000 square miles of the State of California and is nearly 500 miles long. The engineering works include the second highest dam (Shasta) and the second largest pumping plant (Tracy) in the world, one of the world's largest dams at Friant, and two immense canals (Delta-Mendota and Friant-Kern). A summary is given of work now in progress

THE first waterway constructed on the Central Valley Project, the Contra-Costa canal, provides a supplemental supply of fresh water from San Joaquin Delta for cities, industries and agricultural lands in the Suisun bay area where the supplies, in many cases, were damaged by the encroachment of salt water. The canal extends from Knightsen, at the west end of the Rock Slough, westerly along the south side of Suisun bay to a small reservoir above Martinez a distance of 47½ miles, serving en route five municipalities, the important industrial area along the south shore of Suisun bay, and a large area of crop lands in Contra Costa county. The first section is really a tide-water extension of Rock Slough to the first of four pumping plants which lift water from approximately sea level to an elevation of 124 ft.

Construction work on the Contra-Costa canal was started in October, 1937. The first delivery of water from the canal took place at Pittsburg, California, in August, 1940, when a turnout gate was opened to release water from the canal to the city's water main. This event was significant because it marked the first delivery of water on the Central Valley Project. A 38-mile section of the canal was completed at that time. Construction of the canal to its full length was completed in December, 1948.

The canal at its intake has a capacity of 350 cusecs., which is reduced in the 47½ mile length to 22 cusecs. at its terminus at Mountain View reservoir near Martinez.

Numerous structures were required in the first 20 miles of the canal. Prominent features include a headworks structure, a 1,360-ft.-long tunnel, two railroad crossings, approximately 50 reinforced-concrete syphons and other structures. Only the first 3·7 miles of the canal, leading to the first pumping station, are unlined.

One of the features of the lining of the canal was the installation of two experimental sections of asphaltic concrete lining.

Two canals—the Clayton and the Ygnacio canals—are integrated into the Contra-Costa canal system. The Clayton canal, about 4½ miles long, carries water at a capacity varying from 38 to 11 cusecs. The Ygnacio is about five miles long and carries water at a capacity from 30 to 9 cusecs.

Madera canal

Construction work began on the Madera canal in December, 1940. While most construction for irrigation was stopped in 1941 with the outbreak of World War II, work on the first eight miles of the canal was allowed to continue. This section, concrete lined, was completed in December, 1942. The entire reach of the canal, 37 miles long, was completed in June, 1945.

Madera canal diverts water northerly from Millerton lake to furnish a supplemental and new irrigation supply to lands in the Madera Irrigation District. In its upper reaches, the Madera Canal is concrete lined, 10 feet wide on the bottom, with 1¼ : 1 side slopes. The canal has an initial capacity of 1,000 second-feet, decreasing at the Chowchilla river to 625 second-feet.

Delta-Mendota canal

The Delta-Mendota canal is one of the principal arteries of the Central Valley Project. Its primary purpose is to convey water from the Delta region approximately 117 miles south-easterly and discharge it into the San Joaquin river about 30 miles west of Fresno, at the Mendota pool. (The Mendota pool is a small storage reservoir impounded by a diversion dam on the San Joaquin river. The dam was constructed prior to the building of the Delta-Mendota canal to serve existing irrigation facilities.) The canal water provides a replacement for the San Joaquin river water which now is stored by Friant dam and utilised in the Madera and Friant-Kern systems. In addition, the Delta-Mendota canal supplies limited amounts of water for irrigation of new land and supplements the supply of existing irrigation districts.

The Delta-Mendota canal is one of the largest man-made rivers in the west. It has an initial capacity of 4,600 cusecs. and progressively decreases in size throughout its 117 mile length, discharging into the Mendota pool at a capacity of 3,200 cusecs.

Construction on the Delta-Mendota canal began in 1946 and was completed in the summer of 1951. More than 45,000,000 cubic yards of material was excavated for the Delta-Mendota Canal and its four appurtenant waterways. These wasteways make it possible to drain all or part of the canal and provide spillways for withdrawing flood waters from the canal that might otherwise accumulate.

Structures provided as part of the canal include concrete checks at an average interval of approximately 5 miles, concrete syphons, culverts, drainage inlets, irrigation turnouts, irrigation crossings, and wasteway turnouts. The largest single barrel syphon is the Mountain House syphon located near Tracy, Californa. This syphon is 1,010 ft. long from headwall to headwall, has an inside circular diameter of 24 ft. 3 inches and a 24 inch wall thickness. Approximately 13 million pounds of reinforcing steel are placed

in more than 100,000 cubic yards of concrete in the canal's structures.

Friant-Kern canal

Friant-Kern canal diverts irrigation water southerly from Millerton lake, impounded by Friant dam, to the upper San Joaquin Valley areas which are deficient in water supplies or have no present water supplies.

The canal is the longest waterway on the Central Valley Project, extending 155 miles from Friant dam to the Kern river near Bakersfield, California. It is designed for a capacity of 5,000 cusecs. for the first 54 miles, gradually decreasing in capacity to 2,500 cusecs. at the Kern river. About 85 per cent of the canal is concrete lined.

Canal construction began in September, 1945. In the first three and one-half years of work, 72 miles of the canal, almost half of the eventual total, were completed. The entire canal was completed in the summer of 1951. Water passed southward through a 90 mile reach of the canal for the first time in the summer of 1949 to irrigate farm lands and parts of Fresno and Tulare Counties.

Probably no other canal in history has been built through such a highly developed area. Along the 113 mile reach between the dam and the White river, more than 500 separate and varied structures, including syphons, bridges, wasteways, checks, culverts, overchutes, drainage inlets, irrigation crossings and turnouts have been constructed. Overhead and underground utility lines, such as telephone, telegraph, power, oil and gas, presented individual problems. Over 350 such lines were relocated.

Delta cross channel

The Delta cross channel extends across the Sacramento-San Joaquin Delta. It carries surplus Sacramento river water from the northern to the southern end of the Delta for delivery to the pumping plants on the Contra-Costa canal and to the Tracy pumping plant on the Delta-Mendota canal. It also facilitates the distribution of fresh water in the Delta for salinity control and irrigation.

The Delta region in California is a roughly triangular tract of land lying just to the east of Suisun bay. This area, which extends for a distance of about 50 miles north and south and has a maximum width of about 25 miles, was originally a marsh with a network of channels threading through it. At the present time, the Delta is agricultural land which has been reclaimed by constructing dykes along the old channel to enclose areas which can be pumped out and farmed. Tides coming into San Francisco bay from the Pacific Ocean expend themselves through Suisun bay and into the Delta channels. In times of flood the salinity is driven back, but in times of low stream flow the tidal ebb and flow succeeds in carrying some salt into the channels. The presence of salinity has been a matter of concern to the farmers of the Delta lands because the ground surface of the reclaimed land is commonly below sea level.

The Delta cross channel begins on the east bank of the Sacramento river in the vicinity of Walnut Grove, California, about 30 miles north of the Tracy pumping plant. Water flows from the Sacramento river into Snodgrass Slough. From Snodgrass Slough the water flows down the north and south branches of the Mokelumne river to the maze of channels and sloughs of the Delta region. Part of the water then flows toward the Pacific Ocean in the San Joaquin river and acts as a repellent to the salt water downstream; the other part of the water is drawn into the Tracy pumping plant.

Contracts for the first stage of the Delta cross channel were awarded by the Bureau of Reclamation in the spring of 1950. This work consisted of about 1 mile of new channel between the Sacramento river and Snodgrass Slough and a floodgate structure on the east bank of the Sacramento river near Walnut Grove.

The transfer of water to the channel is expected to be approximately 2,000 cusecs. for the first two or three years, increasing gradually to approximately 4,500 cusecs. during the first ten years of operation. The floodgate structure consists of a gate section with two 60 by 30 ft. radial gates, an operating bridge, inlet and outlet transitions, and a railroad bridge passing across the structure between the gate section and the outlet transition.

On August 15, 1951, the Delta cross-channel floodgate structure was opened, permitting Sacramento river water to flow to the Tracy pumping plant for the first time, and observations of the rate of flow and of salinity began.

The problem of introducing fresh water into the maze of rivers and sloughs of the Delta region in the

Fig. 5. An aerial view of Contra Costa canal

Fig. 6. The Friant-Kern canal--the longest waterway in the Central Valley project

Fig. 7. Offtake of the Delta cross channel nearing completion, on the bank of the Sacramento river

best locations and in a sufficient quantity to repel the salt water and supply the Tracy pumping plant was an unusual one and resolved itself into the following component parts: quantity of water required; type of diversion; location and size of the diversion channel.

To determine the location and size of the channel, it was necessary to solve a means of bringing the Sacramento river water across the Delta to the San Joaquin side without upsetting the balance of forces which now hold the salinity in check. One of the first methods of attacking the problem was by means of a hydraulic model. A tide-generating apparatus and means for introducing stream flow were provided. Dyes were introduced to represent salinity. Flow patterns in the Delta were extensively studied with this model, both for historic conditions and for the anticipated conditions as altered by the pumping. The model also provided a means for testing analytical procedures for estimating salinity propagation.

Other cross-channel studies included an adaptation to open channels of the Hardy Cross method of successive corrections for flow of water in pipe networks; an analysis based on hydraulic wave motion; an electric power analogue; and a network analyser normally used for the solution of electrical transmission-line problems.

Irrigation Distribution Systems

Development of the distribution systems for irrigation on the Central Valley Project has been principally on the Friant-Kern canal distribution system. The construction activity has centred around the irrigation districts formed by the water users adjacent to the canal south of the Kings river.

Current plans call for the development of distribution systems on the Contra-Costa, Delta-Mendota and Madera canals. On the Contra-Costa canal, a system of trunk lines of full-pressure head is to be constructed, from which water users will tie in their own water lines.

Electrical Transmission System

By July 1, 1951, 326 miles of transmission lines on the Central Valley Project had been constructed. Completed is the major 230 kV transmission line on the east side of the Sacramento river, running 232 miles from Shasta dam to the Tracy pumping plant. About 100 miles of the East Side line is of wood-pole construction, and the remaining 132 miles are supported on steel tower structures. The line ties in the power from Shasta power plant and Keswick power plant and transmits it to the Tracy pumping plant. Power to be generated by the Folsom power plant on the American river will be tapped into the West Side line at Elverta, California (near Sacramento).

About 85 miles of the 230 kV, 216 mile double-circuit transmission line, running from Shasta power plant to the Tracy pumping plant on the west side of the Sacramento Valley, has been constructed. It is expected the West Side line will be completed by the spring of 1952.

Outstanding features of construction on the West Side transmission line are the crossings at the Sacra-

mento and San Joaquin rivers near Rio Vista. The Sacramento crossing consists of a 3,810 ft. span supported on double-circuit steel towers about 500 ft. high. The San Joaquin span is 2,300 ft. long supported on double-circuit steel towers about 400 ft. high. Both spans have a clearance of 140 ft. to provide free access for navigation on the rivers.

Also completed in 1951 was the 19 mile 69 kV transmission line running from Tracy switchyard to the Contra-Costa substation. This new line makes it possible to energise the four pumps on the Contra-Costa canal by the use of Bureau of Reclamation power transmitted from Shasta and Keswick power plants. An additional 22 miles of transmission lines were constructed earlier on the Contra Costa system.

New Work on the Central Valley Project

On October 14, 1949, the Congress of the United States reauthorised the Central Valley Project to include the American river development, consisting of the Folsom dam and reservoir (under construction by the United States Army Corps of Engineers), a hydro-electric plant at the dam, an afterbay, and necessary electric transmission lines to the nearest practicable connections with the Central Valley Project transmission system.

Specifications were to be issued about February 1952 for construction of the Folsom power plant. The 162,000 kV capacity plant is to house three 60,000 kVA generators. The semi-outdoor plant is to be a reinforced-concrete structure aboiut 120 by 240 ft. and 107 ft. high. A 275 ton outdoor travelling crane and the embedded parts of three 74,000 h.p. hydraulic turbines are to be installed under the contract. Three 15½ ft. diameter, 200 ft. long penstocks are to be embedded in concrete-lined rock tunnels. Initial excavation of the power-plant area, a part of the tailrace channel and access road have been accomplished under a previous contract.

Also to be constructed on the American river is the Nimbus power plant. This structure is to be located about seven miles downstream from the Folsom power plant. The plant is to be a semi-outdoor type and will house two 7,500 kVA generators. The capacity of the reinforced-concrete structure about 120 by 240 ft. and power plant is 14,000 kW. Also to be constructed is the concrete Nimbus diversion dam. This structure is to be 22 ft. high and 800 ft. long, with eighteen 40 by 20 ft. radial gates. The power plant is to be 120 ft. long and 100 ft. wide. Installation of turbine parts and a 60 ton gantry crane will be included in the contract. Invitations for Nimbus power plant and diversion dam were expected to be issued in April 1952 by the Chief Engineer of the Bureau of Reclamation.

Placed under construction in November 1951 were the Columbia No. 1 and Mowry pumping plants. These structures are outdoor type pumping plants and are features of the Columbia and Mowry delivery canals on the Delta-Mendota canal distribution system. The 195 cusecs. Columbia plant No. 1 is to contain six pumps, and the 10 cusecs. Mowry plant is to have two pumps.

Specifications were anticipated to be issued in May 1952 for construction of about 19 miles of 12 to 36 in. diameter reinforced-concrete and concrete irrigation pipelines for the Stone Corral Irrigation District. A small amount of pumping under a 125 ft. head will be necessary to irrigate about 200 acres of the system, but the balance will operate under heads up to 25 ft. In June invitations were expected to be issued for construction of 63 miles of precast concrete pipelines of 124 to 72 in. diameter for Unit 2 of the Delano-Earlimart Irrigation District. The contract is to include construction of monolithic concrete structures for four low-head pumping plants, totalling 20 cusecs. capacity, and one 150 cusecs. pumping plant.

English Electric Co. Ltd. gets Central Valley Contract

The English Electric Co. Ltd. has been awarded a contract by the U.S. Department of Interior's Bureau of Reclamation to construct a fourth large transformer for the Folsom power plant switchyard on the Central Valley Project in California. The award to the English Electric Company, the low bidder, was to provide in 730 days an 80,000 kVA auto-transformer, and it will be the first non-American equipment to go into the big hydro-electric project. The contract will result in an apparent saving of more than six months' time in providing the Folsom plant facilities which have been geared for installation by the Bureau of Reclamation to meet the defence and kilowatt schedules submitted to the Congress and California's power demands. The dam and power plant on the American river near Sacramento, when completed, will provide more than 160,000 kW of vitally needed hydro-electric power capacity for domestic, municipal, industrial and defence plant used in the region.

The English Electric Company, submitting a bid of $302, 912.50, was evaluated low among five bidders for the work, and was the only bidder stating that delivery would be made within the time specified, Reclamation Commissioner Michael W. Straus pointed out. A second supplier who would manufacture the auto-transformer abroad, the Ferranti Electric Company, Inc., of New York, was second low evaluated bidder, but did not offer delivery in accordance with the specified time schedule, Mr. Straus pointed out. The Ferranti Company also would manufacture the transformer in England. The Westinghouse Electric Corporation was third evaluated bidder and low among the three domestic manufacturers. The low evaluated bid was the only one received stating that shipment would be made within 730 days, as required in the invitation, in order to meeting existing schedules for power generation. The other bidders stated shipment as follows: Westinghouse, 917 days; General Electric, 930 days; Allis Chalmers, 1,100 days; Ferranti Electric, 1,160 days. The low foreign and the low domestic evaluation bids were: English Electric Company, $302,912.50; Westinghouse, $331,410.57.

The Folsom power facilities in California are being constructed by the Bureau of Reclamation at a total estimated cost of $36,821,000. Under Reclamation law the cost of installation is reflected in power rates and any savings are passed on to consumers. The Folsom power plant will include three 54,000 kW generators, and bids for construction of the power-plant building were opened on April 2.

The U.S. Department of Commerce noted that English Electric's progress on its new contract work no doubt would be closely watched by many in the United States.

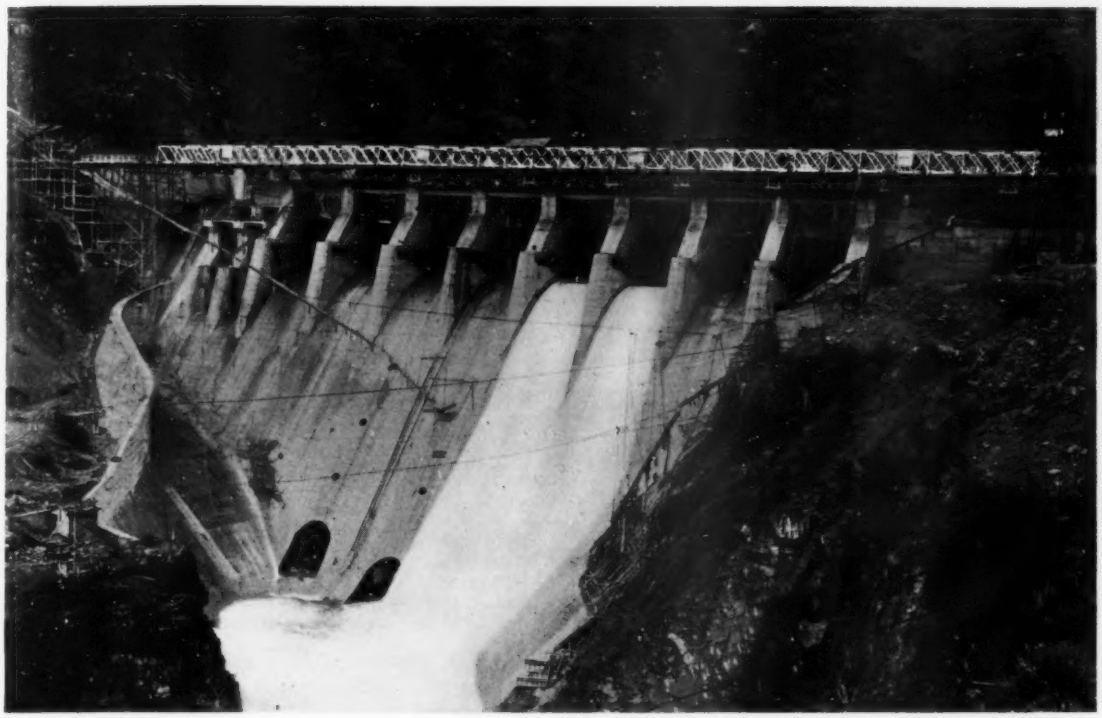


Fig. 1. Dam serving the Narude 35,000 kW plant of the Kansai Power Co. Ltd. The dam is 51·3 m. high and 88·8 m. long

Power Problems in Japan

A general survey of the power position, with special reference to hydro-electric development, is given by our Special Correspondent in Tokyo

JAPAN, a country around 80 per cent of which is mountain and rock, with one of the highest hydro-electric potentials in the world, has since the end of the Pacific war been suffering from an acute shortage of electric power for its industries and cities.

This shortage had its genesis in pre-war days when, following the Manchurian invasion of 1931 and Japanese expansion in North China, the nation concentrated on developing the hydro-electric resources of those regions and Korea, while the needs of Japan proper, alike for power and domestic current, took a back seat. Thus it happened that although wartime destruction of Japan's electricity installations was not heavy, apart from some 17 per cent. of the nation's thermal units being put out of commission, the end of the war and the resumption of peacetime industrial production found the electric power industry faced with a tremendous increase in consumption with no corresponding expansion in progress.

Development of the needed additional resources was further impeded by uncertainty whether thermal equipment would be earmarked for reparations to China and the Philippines. The occupation authorities failed to realise the size of the backlog, the necessary funds were not available for large-scale construction, and by 1948 consumption had so far outstripped production that power cuts and "brownouts" had become routine in a nation possessing more abundant water-power resources than most of the world's countries. Those power cuts still continue; they are happening daily in the Kanto Plain region, in which Tokyo is located.

For some time the Japanese authorities were undecided whether to revive the Japan Electric Power Generating and Transmission Company—the power monopoly established by the military during the war—or to return the industry to private hands. This question was fought over for four years. Finally, on November 22, 1950, General MacArthur issued an order regarding the acceleration of the reorganisation of the Japanese electric power industry, and on November 24, 1950, the Electric Enterprise Reorganisation Order and the Public Utilities Order were promulgated and the policy for reorganising electric power enterprises thus decided.

On December 15, 1950, a Public Utilities Commission was inaugurated as an administrative organ to preside over the industry, with five members: Mr.

George Matsumoto (former Minister of Commerce and Industry) as Chairman; Mr. Yasuzaemon Matsunaga (former President of the Toho Electric Power Co.) as Chairman of the Electrical Enterprise Reorganisation Council; Mr. Kiyoshi Miyahara (President of the Kamijima Chemical Co.); Mr. Koichi Kawakami (President of the Export-Import Bank), and Mr. Chubai Ito (former President of the Daiken Industrial Co.), the latter an expert who had studied for seven years in England. This Commission concentrated its efforts on the tasks of reorganisation, completed the establishment of nine independent and integrated companies serving various regions of the country by May last, authorised the revision of new power rates, and has since been engaged in expediting the development of power sources. The whole machinery thus created represented an amalgam of the type of organisation existing in the power industry in the United Kingdom and the Federal Power Commission in the United States.

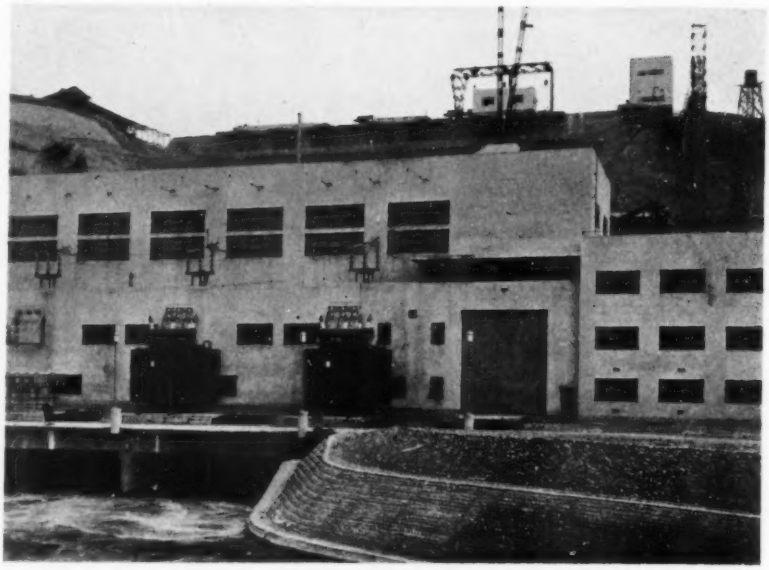


Fig. 2. The Ojiya plant owned by the Japanese Government Railway

The present status of demand and supply in Japan has been outlined by the Commission as follows:

"The necessary development of new power sources has progressed slowly and only recently has there been any definite indication of improvement in the situation. As existing power sources have already been taxed to the limit, there is a marked unbalance of demand and supply. The government has been forced to control and allocate power which, augmented by the natural tendency for limitation of consumption due to shortage of supply, results in the actual restrained situation. Although the latent demand cannot be accurately gauged, it is estimated that uncontrolled use of power will necessitate 10 to 15 per cent increase of power generation and a 20 to 25 per cent increase in maximum power.

Fig. 3. The Ojiya generator room showing the two 25,000 kW sets. Space is available for a third set to be installed in the near future

"Total generation capacity developed in Japan is 10,540,000 kW as at the end of January, 1951. Because the Japanese power industry developed its power sources in order to meet the demands of lighting consumers, Japan has a great many comparatively small-scale power-generation plants. But with the lapse of time, an increasing demand from power consumers necessitated the construction of power plants designed to meet the new-type demand, and, at the same time, progress of construction technique and electrical engineering has enabled the development of large power sources. Especially with the modernisation of industries, power development constructions are inclined towards large-scale reservoir-type power plants.

"Among the above-mentioned total capacity, the capacity of power plants for general supply is 8,750,000 kW, of which hydro and thermal facilities generate 5,920,000 kW and 2,830,000 kW respectively. Among the former, 480,000 kW consists of reservoir-type plants."

A complicating factor in coping with the increasing national demand (estimated at 34.9 billion kWH in 1952; 37·9 billion kWH in 1953; 41·0 billion kWH in 1954, and 44·3 billion kWH in 1955) is the fact that Japan's thermal units were constructed only as auxiliaries for the limited purpose of alleviating power shortages during the low-water seasons and not to operate continuously. Japanese coal production is insufficient to supply the thermal units when operating

for long periods, and since the Pacific war the nation has been importing coal from India (at $22 per ton c.i.f.) to keep them operating to capacity. This uneconomic price for coal in turn caused power prices to rise with resultant objections from Japanese industries accustomed to cheap power.

This, in brief, was the situation which the Public Utilities Commission inherited. At the time the Commission came into existence, it was faced with the twin problems of alleviating the shortage of power and current as speedily as possible and, further, planning a programme of development which has been estimated to require the investment of the equivalent of $2 billions in new generating capacity over the next five years.

The Commission decided that, if the first problem was to be solved, Japan could not wait to build the dams and hydro installations which should have been constructed during the war years, but must build more thermal plants.

Here again, there are complications. Japanese manufacturers of the equipment needed are in many cases heavily engaged in work on export orders, and so Japan is having to go to the United States and Germany, and maybe the United Kingdom, in search of needed equipment. The situation is said to be extremely difficult because of the world shortage of power.

Plans for the development of the Japanese industry call for the formation of a special Power Development Company, probably financed largely by government money, but for no big alleviation of the position before 1954, after which date the power generated will increase steeply until 1959.

A thermal unit requires only eight to fifteen months to construct, whereas over two years are needed to build a large hydro-electric installation. It is therefore planned, as a first step, to provide for a speedy increase in thermal capacity, which is to be increased, if plans mature, by 100 million kWH per annum within three years to a total, in 1956, of between 600 and 700 million kWH per annum. Simultaneously, there will begin a big-scale development of hydro-electric expansion aided by machinery imported from the United States. These two operations together will, it is hoped, overcome the present deficit in meeting national demand (amounting to 50 million kWH with controlled consumption) by 1957.

As a start, since the reorganisation of the industry, 410,000 kW of new construction has been completed in six months, compared with 50,000 kW in the preceding six months.

The biggest hydro-electric construction job yet begun, and the biggest ever undertaken in Japan, is the Maruyama plant in the Kiso river valley in Gifu Prefecture, recently resumed by the Kansai Electric Power Company after years of suspension due to war.

The plant, equipped with two generators, will be constructed at an expenditure of more than 10 billion yen. After completion, scheduled for March, 1954, it is expected to yield a maximum power output of 105,000 kW, the average output being 31,500 kW. The total annual supply of electricity will amount to 603,400 kWH.

The storage dam, 88 m. high and 240 m. long, will be capable of keeping in reserve 59,350,000 cu. m. of water, of which 18,220,000 cu m. will be effectively utilised with a head of 81.15 m.

Winnipeg Electric Company's Report

According to the 59th Annual Report (1951) of the Winnipeg Electric Company, gross revenue from the sale of electricity after deduction of inter-company transactions amounted to $8,180,289, an increase of $501,505, or 6·53 per cent., over the previous year. Operating expenses, excluding taxes and depreciation, amounted to $1,997,500, an increase of $1,539. This increase would have been considerably greater due to increased wage rates and the company's contribution to the pension fund covering a full year instead of a half-year as in 1950, except that 1950 expenses included heavy charges for flood and storm damage.

There was a net increase of 5,972 services during the year. Of these 1,882 were for lighting, 1,820 for cooking, 2,142 for water heating and 128 for power. In addition, Manitoba Power Commission bought 21·7 per cent. more kilowatt-hours than in the previous year, and a number of industrial concerns increased their connected loads.

The company has two hydro-electric plants on the Winnipeg river, Great Falls with an installed capacity of 168,000 h.p. and Seven Sisters with an installed capacity of 225,000 h.p. when completed this summer by the installation of the sixth unit. The original plant on the Pinawa channel, which commenced operation in 1906 and at its peak had a capacity of 30,000 h.p., was finally closed down in September in order to allow the full flow of the river to be used through the Seven Sisters plant at the increased head.

The peak load on the system during the year was 389,410 h.p. and the total power generated was 1,706,966,537 kWh. In addition, the company purchased 3,034,100 kWh from the Manitoba Government's Pine Falls plant which it operates on a temporary basis by agreement with the Manitoba Hydro-Electric Board.

Capital expenditures on the Electric Utility for the year amounted to $1,661,911.93 of which $850,547.21 was for Seven Sisters.

Portuguese Power Company equipped with V.H.F. Radio

An interesting example of the use of the V.H.F. radio in connection with power systems is given by the communications network which The General Electric Co. Ltd., England, supplied to the Hydro-Electrica do Alto Alentejo in Portugal. The power company at present has thirteen radio stations, three with output powers of 100 watts and ten of 15 watts, five of the latter being mobile stations. All the transmitter receiver stations work on telephony, and after more than two years of regular use have proved to be of substantial value in the operation and maintenance of the power system.

Blaw Knox Limited. Publication No. BK-154 issued by this firm relates to the Hydraulic Angledozer for Fowler Challenger III Tractor; No. BK-155 to the Cable Angledozer for Fowler Challenger III Tractor; and No. BK-156 to the Hydraulic Angledozer for Fowler VF Crawler Tractor. All these leaflets supersede the previous leaflets, which should now be discarded as obsolete, on these items of equipment.

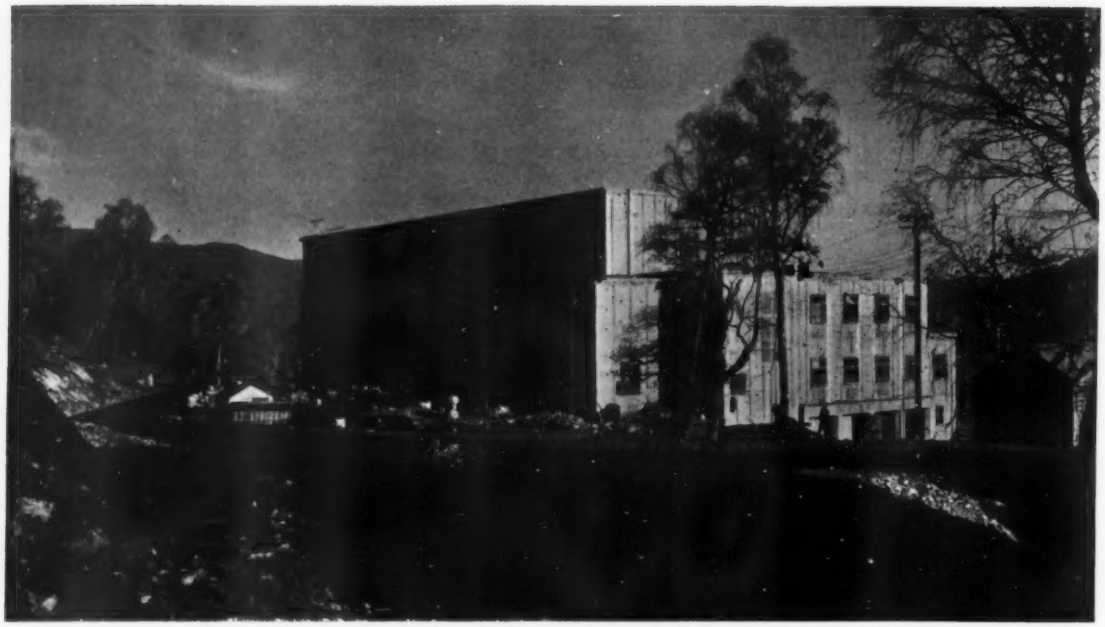


Fig. 22. A view of Fasnakyle power station from the new road

The Glen Affric Scheme

In this concluding article we describe the Fasnakyle generating station

PART THREE

FASNAKYLE generating station, depicted in Fig. 22 is situated on the river Glass. As the site is on the edge of a bend, model tests were undertaken to ensure that silt would not be deposited at the draught-tube outlets and that serious scour would not occur when the relief valves operated.

The building is 232 ft. long, 68 ft. wide and 54 ft. high above road level, and is a steel-framed reinforced-concrete structure. It is faced with a golden yellow sandstone from Burghead—a beautiful stone which harmonises perfectly with its surroundings. An interior view of the station is given in Fig. 23, which shows the three English Electric 22,000 kW sets forming the generating equipment.

The main valves controlling these sets are an interesting development, for they are of a new design introduced by The English Electric Co. Ltd., and are the first of this type to be put into commercial service in Great Britain, although several have been exported, including one 19 ft. 6 in. high. Drawings of the valve are given in Fig. 24.

The valve is of the straightflow type, and the door is roughly hemispherical, one half of this hemisphere being solid and acting as the closing member whereas the other half is bored out to the diameter of the pipe and forms the follower ring. Thus the valve is claimed to combine the characteristics of a spectacle-eye sluice valve, in that it cuts cleanly through the water without diverting the jet, with the compactness and small frictional resistance to movement of the rotary valve. In the full open position the valve presents a smooth unobstructed bore to the water flow.

The door is of cast steel with weld-deposited stainless-steel seating faces. The service seal bears on the downstream side, is operated by pipeline pressure, and is claimed to be drop-tight. It can be attended to or replaced *in situ* behind the protection of a positive screw-operated emergency seal bearing against the upstream side of the door. Both seals are of reinforced rubber clamped between metal surfaces, and we are informed that a seal of this design has been proved drop-tight at a pressure of 700 lb. per sq. in.

The valve body is fabricated in halves, and the trunnion bearings are gunmetal lined. The servomotor is constructed of mild-steel plate with a stainless-steel protective layer added in the rolling mill. A slowing-down device is included in the valve control gear so that excessive waterhammer pressures are not developed when closing against full discharge under emergency conditions. The water to supply the servomotors operating these valves and the bypass valves is derived from the high-pressure tunnel.

The turbines are of the vertical-shaft Francis type developing 33,000 b.h.p. at 375 r.p.m. at a head of 490 ft., the maximum net head being 510 ft. and the gross static head 525 ft. Provision is made to run

any alternator as a synchronous condenser, in which event the spiral casing is emptied and the runner seals are supplied with cooling water. All the spiral casings are fabricated, the first having been delivered in halves and welded together on site, the other two being delivered in one piece. The turbine runners are of cast stainless steel with separate shrunk-on labyrinth sealing rings. The guide vanes are fabricated, and are controlled in the orthodox manner from an external regulating ring through breaking links. A standard English Electric actuator is employed, driven by a synchronous motor from a permanent-magnet alternator carried on the exciter shaft.

A guide bearing for the turbine shaft is carried on the top cover of the turbine, and is force lubricated by a gear-driven pump. An automatic d.c. motor-driven standby pump is available to cover starting up, shutting down, and failure of the main pump.

Transverse fitted keys are used in the couplings between turbine and alternator shafts, thus dispensing with fitted bolts.

Each alternator is rated to generate 22,000 kW at 11kV at 0·95 power factor. A concrete plinth carries the stator, through which is transmitted the load on the thrust bearing, amounting to 185 tons. The rotors were transported to site in parts, the steel plates being shrunk on to the shaft and the poles placed in position at the station. Each rotor weighs 116 tons. The machine construction is of the two-bracket type, the upper bracket carrying the thrust and upper guide bearings and the lower bracket the lower guide bearing and the brakes. Oil supply to the alternator bearings is separate from that for the turbine bearing, and is derived from an a.c. motor-driven pump with a d.c. motor-driven pump as standby, a water cooler being included in the circuit.

The brakes are Ferodo lined, and are operated by compressed air at 55 lb. per sq. in. obtained through a solenoid-operated valve and a reducing valve from a compressor common to all three sets. This set can also deliver air at 300 lb. per sq. in. to the governor-oil receivers when required. A hand-operated pump delivers oil to the brakes at 2,000 lb. per sq. in. when it is desired to jack up the rotor to inspect the thrust bearing.

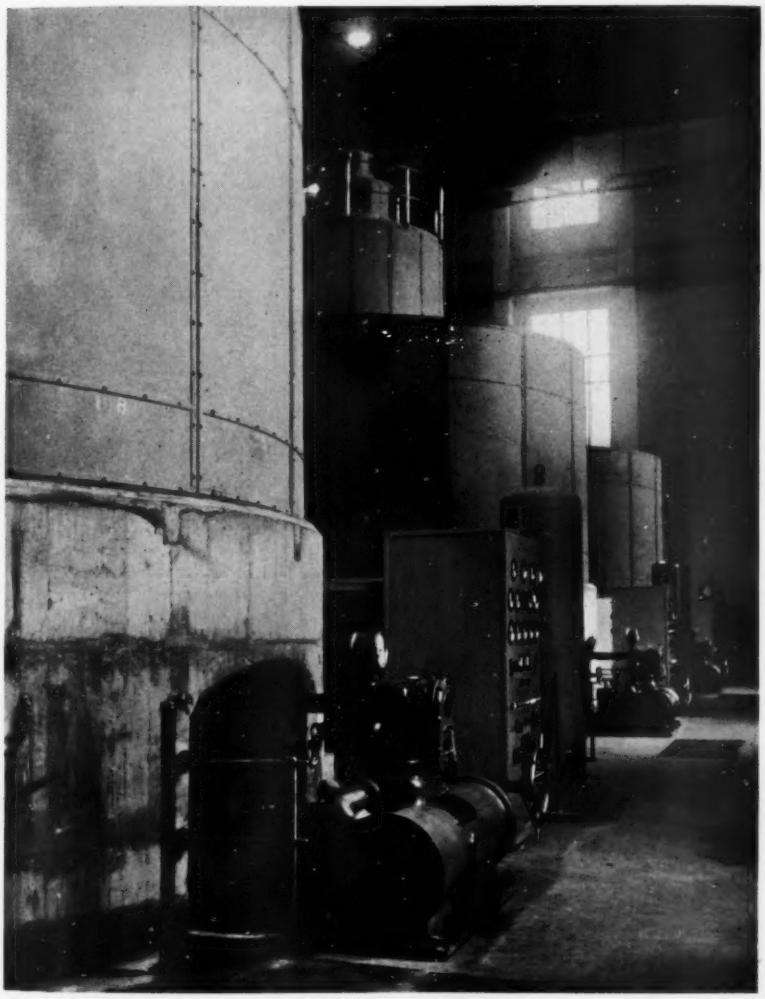


Fig. 23. Interior of Fasnakyle station showing the three English Electric 22,000 kW sets

Main and pilot exciters surmount the alternator, and on the extremity of the exciter shaft is the governor alternator. As already stated, this is a permanent-magnet machine, but magnetising windings are provided on the rotor poles for initial magnetising and for remagnetising if necessary.

The oil system of each governor gear is maintained by its own a.c. motor-driven pump, but a standby Pelton-driven pump is provided for the station, starting automatically if the oil pressure falls below a predetermined value.

The alternators are cooled on the closed air-circuit system, each set being provided with a motor-driven pump drawing water from the draught tube, and passing it through six vertical coolers. A standby supply is available from the spiral casing through a reducing valve. Manually operated CO_2 fire-protection equipment is provided and is under the control of the operator from the turbine gauge panel. About 25 per cent. of the circulating air can be extracted for station heating, entering the turbine room through gratings in the floor.

Essential auxiliaries for each set are supplied on the unit principle through a 250 kVA 11,000/415V transformer solidly connected to the alternator terminals, so

that these auxiliaries run up to speed with the set. A standby supply for these auxiliaries is available from a similar transformer fed from the 11 kV line from Kiltarlity, a system of interlocking contactors automatically choosing a healthy supply.

Any of these four transformers can also be used to feed the common-services board through hand-operated isolators. This board is of the switch-fuse type, and supplies 19 feeder circuits (including five spares) at 415/240 V three-phase four-wire.

Direct current for standby auxiliaries, control and indicator circuits, and telephones is supplied from batteries at 110 and 50 V.

Main Electrical System and Control

A key diagram of the main and auxiliary circuits is given in Fig. 25. The main transformers and H.V. switchgear are located in an outdoor switching station (Fig. 26) about 300 yards down the Cannich road from the station. Each alternator is connected direct to a 28,158 kVA 11/132 kV transformer by three trefoil groups of 11 kV p.i.l.c. underground cables. The transformers have forced oil and forced air circulation through external coolers and have no natural cooling. Switching is at 132 kV, the station being arranged on the single-busbar system with five pneumatically operated oil circuit breakers of 1,500 MVA rupturing capacity, three breakers controlling the generators and the others two feeders to Beauly. Space has been left to change over to a duplicate-busbar system at a later date.

A 132 kV line has also been built to Fort Augustus, but at present it is being used as a construction line and is fed at 33 kV from one or other of the 132 kV Beauly feeder circuits through two Metropolitan-Vickers 7·5 MV transformers. Ultimately this line will form an additional circuit in the main 132 kV system.

We have previously mentioned that the voltage of the Cannich-Fasnakyle-Benevean 11 kV line will ultimately be raised to 33 kV. When this is done a 33 kV outdoor substation will be erected at Fasnakyle and will link in the Fasnakyle-Kullardoch line.

Auxiliary power for the switching station is derived from four 150 kVA 11,000/415 V transformers, three being unit transformers permanently connected to the L.V. side of the main transformers, and the fourth giving a standby supply from the Cannich-Benevean line. Apparatus for the automatic selection of a healthy circuit is also installed here.

Protection and control circuits are energised from

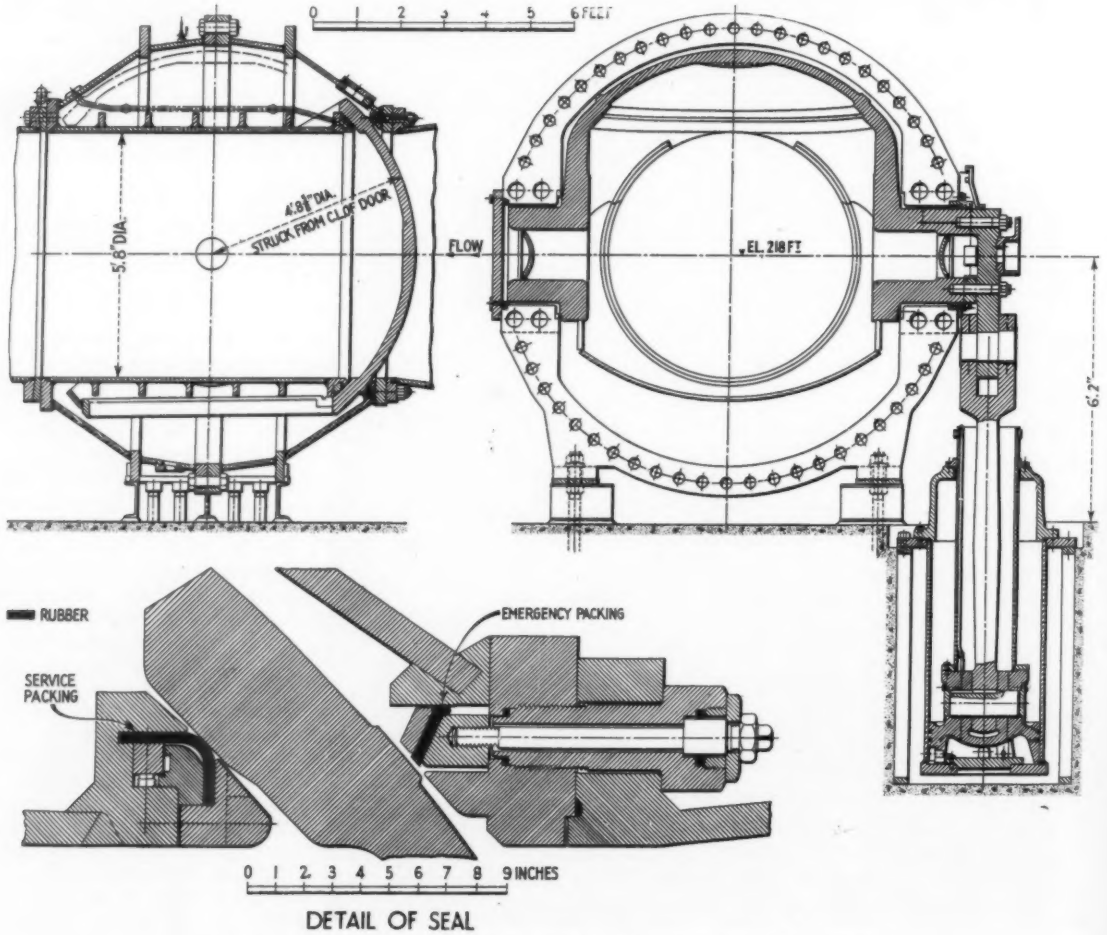


Fig. 24. Arrangement of the English Electric straightflow valve

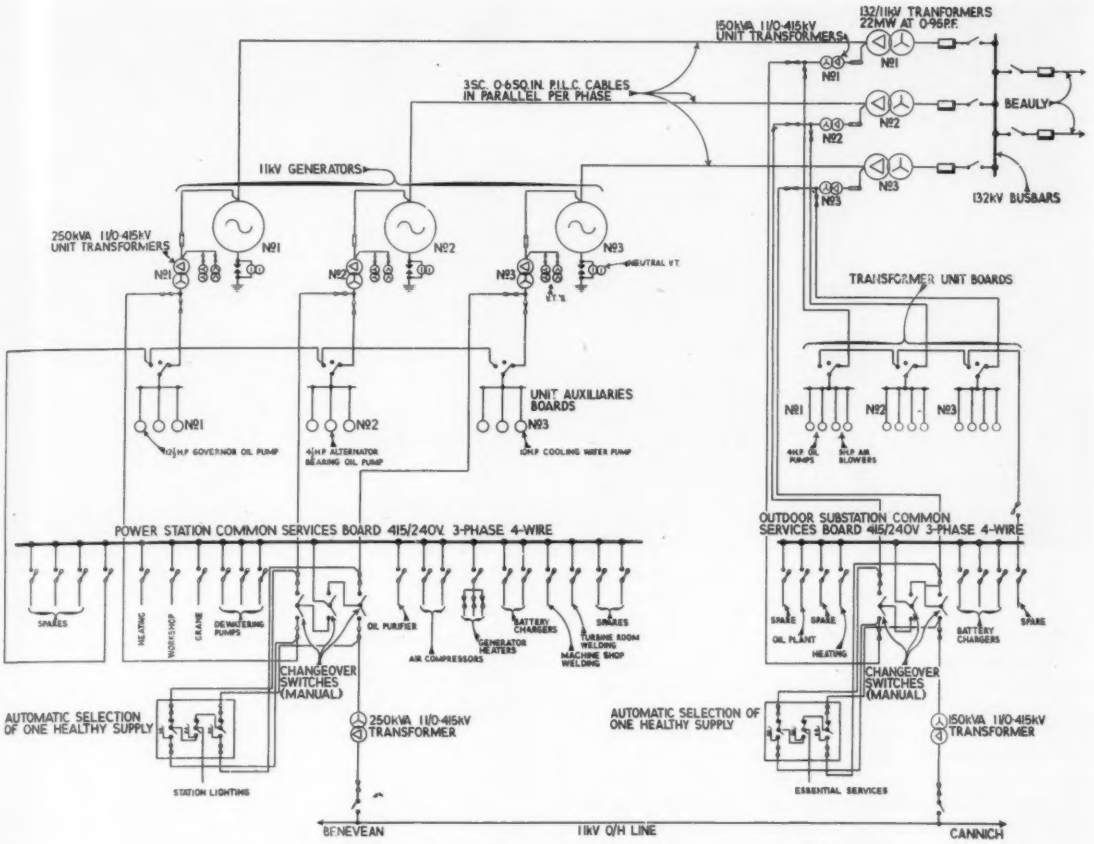


Fig. 25. Main and auxiliary circuits of Fasnakyle station

Fig. 26. A general view of Fasnakyle switching station

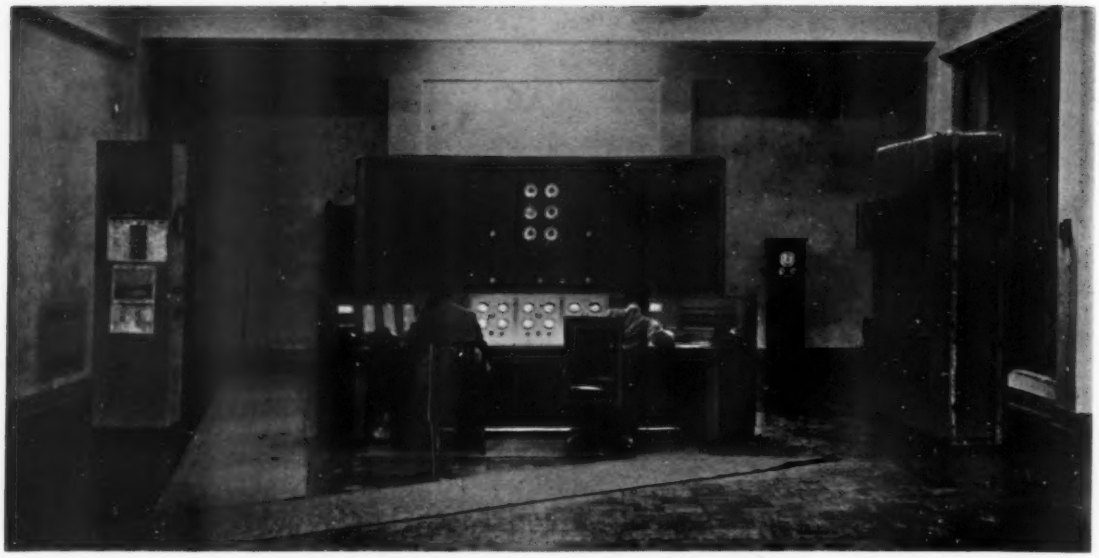


Fig. 27. The control room in Fasnakyle station

batteries at 250, 110 and 50 V.

A single-storey building faced with Burghead stone contains the switching-station offices and laboratory, and accommodates the common-services board, batteries and protective relays. Translay protection covers the zone from the generator neutrals to the busbar side of the generator breakers, including the generator windings, cables, transformers and breakers. Negative phase sequence protection is also included for the generators. The busbars are provided with a simple form of single-zone bus-zone protection, and protection of the feeders is by telephone equipment using carrier currents with back-up overload protection.

All control and switching operations are centred in the control room, depicted in Fig. 27, which is located on an upper floor of the generating station and commands a view of the power house. A control board arranged in the form of a mimic diagram shows the condition of the main electrical system and of the sets themselves and provides for synchronising, switching and load control. In front of this board is a desk carrying controls and instruments for controlling the load, speed, voltage and power factor of each machine. All the control gear uses light-current telephone-type circuits operating at 50 V, and a comprehensive system of protective alarms covers every conceivable mechanical or electrical fault. Any fault that develops is indicated aurally and visually in the control room, and those with which the turbine driver is concerned are also indicated on the instrument board adjacent to the particular machine. A panel to the right of the control desk carries the Metropolitan-Vickers voltage regulators for the three generators, and one on the left shows the vital hydraulic conditions.

Acknowledgments

We have much pleasure in acknowledging the kindness of the North of Scotland Hydro-Electric Board in affording us full facilities to inspect the works, in placing photographs at our disposal, and in permitting us to publish these articles.

The consulting engineers for the civil and for the mechanical and electrical sides of the work respectively are Sir William Halcrow & Partners and Messrs. Kennedy & Donkin, and we are greatly indebted to both of these concerns for much valuable assistance. The architects for the scheme are Messrs. James Shearer & Annand. John Cochrane and Sons Ltd. are the main civil-enginering contractors, and The English Electric Co. Ltd. the main contractors for the mechanical and electrical equipment. A list of the principal manufacturers concerned is appended:—

Turbines, alternators and main valves	The English Electric Co. Ltd., Stafford. (Much of the plant was manufactured in Scotland at the works of Harland & Wolff Limited, Glasgow.)
Roller gates, emergency gates, screens, needle valves, sluices and miscellaneous valves	Glenfield & Kennedy Limited, Kilmarnock.
120 ton electrically operated crane	Sir William Arrol & Co. Ltd., Glasgow.
Main power cables and auxiliary cables	Scottish Cables Limited, Renfrew.
Main and auxiliary transformers	The English Electric Co. Ltd., Stafford.
132 kV switchgear	The English Electric Co. Ltd., Stafford.
Power station and switching station batteries	Pritchett & Gold & E.P.S. Ltd., London.
Miniature direct control equipment	Standard Telephones & Cables Limited, London.
L.T.A.C. and D.C. switchgear and auxiliaries in the power station	The English Electric Co. Ltd., Stafford.
Automatic voltage regulators	Metropolitan-Vickers Electrical Co. Ltd., Manchester.
Lighting and heating in the power station and switching station	James Scott & Co. (Electrical Engineers) Limited, Perth.
Pilot cable for dam gate controls and indications	Pirelli-General Cable Works Ltd., Southampton.
11 kV wood pole lines	J. L. Eve Construction Co. Ltd., Wimbledon.

Book Reviews

Irrigation Outlets. By S. I. Mahub, I.S.E., K.B., M.I.E. (India), and N. D. Gulhati, I.S.E., M.I.E. (India). Published by Atma Ram & Sons, Kashmere Gate, Delhi. 9¼ in. × 6½ in. × ½ in. 184 pp. (with index). Illus. Price Rs. 12/8/-.

This book had its origin in 1943 when the joint authors, who were employed in the Irrigation Branch Secretariat of the Public Works Department, decided to collect all available information on the design and construction of different types of irrigation outlets for presentation as a paper to the Punjab Engineering Congress of 1944. Subsequently the material has been revised, rearranged and much new information incorporated by one of the authors, Mr. Gulhati, who is thus largely responsible for an authoritative textbook on this rather tricky subject. We say tricky because the outlet is connecting link between the individual irrigation channel and the major canal system which is more often than not government owned, and if difficulties are to be avoided its design and construction call for every care. The book affords an excellent guide to good practice and can be recommended to those hydro-electric engineers who have to deal with multiple-purpose projects.

Comparison between British and American Standards for the Short-Circuit Rating, Performance, Selection and Testing of Oil Circuit Breakers. The Association of Short-Circuit Testing Authorities, Inc. 36 & 38 Kingsway, London, W.C.2. Price 10s. net.

The requirements of British and of American Standards for oil circuit breakers differ so widely that, unless these differences are clearly understood, a comparison between units conforming respectively to British and to American specifications may be quite misleading. For example, American ratings are based on the asymmetrical breaking current whereas British ratings are based on the symmetrical breaking current, and in many other directions the British specification is more stringent than the American. Thus a British unit will show to disadvantage on paper as against an American unit with which it is actually comparable.

In the publication under review these differences are set out clearly and in detail, enabling a true comparison to be made in any given circumstances. The publication should be valuable both to manufacturers and to purchasers of switchgear.

Civil Engineering Reference Book. Edited by E. H. Probst, D.Eng., M.I.C.E., and J. Comrie, B.Sc., A.M.I.C.E. Butterworths Scientific Publications Limited, Bell Yard, Temple Bar, London, W.C.2. 1952. xii + 1703 pp. Many ff. and tt. Price £7 7s. net.

This journal is concerned with a subject which extends over wide fields in science and engineering, and indeed reaches beyond, into legal, administrative, industrial spheres and even into the realm of international technical co-operation. The reader with an understanding of the many facets of hydro-electric engineering will find that the breadth of knowledge required makes it difficult for him to be a master of detail in more than a few fields. It is for this reason that the present reference work will be especially welcome to water-power specialists. Engineers with a civil-engineering background will be able to refresh their knowledge of theory and to study modern aspects of civil-engineering practice, with bibliographies at the end of each chapter pointing the way to greater detail of any one subject. Engineers with primarily mechanical or electrical interests, on the other hand, will find in the book explanations of many of the civil-engineering problems which they encounter in their efforts to integrate their work in the field of water-power engineering.

Mention should here be made of the many subjects which are of direct concern to water-power specialists, although in a review of this volume of over 1,700 pages, it is hardly possible to list the 48 chapters and their contents, or to mention all the authors, many of whom are well-known authorities in their own fields.

The beginning of the book covers the scientific fundamentals of civil engineering, and the first chapter, by Mr. D. J. Davies, deals in 75 pages with Mathematics. This is followed by a brief chapter on Statistics, by Dr. H. O. Hartley, and longer ones on the Mechanics of Solids, by Dr. H. Parkus and Dr. E. Chwalla; on the Mechanics of Fluids, by Professor Jack Allen; on the Strength of Materials, by Chwalla and Parkus; and on Thin Slabs and Shells, by Dr. K. Girkmann. It is interesting to note that some chapters have been contributed by experts from the Commonwealth and from the Continent of Europe, whose experience and method of approach appear to be different from those of the British contributors. This diversity greatly enhances the value of the book and will be particularly welcome to the engineer who cannot find time to study scientific papers from abroad.

A 100-page chapter on the Theory of Structures, by Dr. H. Gottfeldt, represents a happy synthesis of British and Continental methods of solving problems of structural design. Dr. H. Q. Golder contributes a chapter on Soil Mechanics, Mr. R. Glossop a note on Site Investigation, and Dr. Guthlac Wilson a major chapter on Foundations and Earthworks. Surveying has been covered by Mr. J. Clendinning, and Building Materials and Cements are dealt with by Dr. T. W. Parker. A group of chapters by Mr. D. J. Davies, Dr. H. Gottfeldt, Mr. W. S. Atkins and Mr. H. V. Hill, is devoted to steel structures, and another group to concrete construction. Here the leading contribution comes from Professor Probst himself, the man who inspired and, with Mr. Comrie's assistance, organised the task of producing this reference book, but died before its publication.

Other structural materials are covered in chapters on Light Alloy Construction, by Mr. R. A. Foulkes, and on Timber Construction, by Mr. C. F. Morrison; although short, they will be found valuable for quick reference on subjects not easily accessible.

Applied hydraulics and hydraulic structures are dealt with in chapters on Canals, Channels and Rivers, by Mr. T. Blench; on Coasts, Estuaries and Tidal Hydraulics, by Dr. J. van Veen; on Land Drainage (including some hydrology), by Dr. G. R. MacKay; on Waterways Construction and Operation, by Mr. C. A. Wilson; on Harbours and Docks, by Mr. D. H. Little; and on Water Supplies by Mr. R. C. S. Walters.

For those interested in construction, there is a chapter on Works Construction, by Messrs. C. L. Champion and J. H. W. Turner; on Explosives, by

Mr. R. Westwater and Dr. G. Morris; on Tunnelling Practice, by Mr. H. D. Morgan; and on Tunnelling in Switzerland, by Mr. C. Andreae. Mr. A. Johnson has written on Specifications and Quantities, and Mr. C. Roland Woods has contributed British Legal Notes.

Full mathematical and structural tables are appended and the elaborate conversion tables will be found most useful by engineers engaged on work for countries overseas.

The editor's introductory note mentions that it had proved impossible to include a chapter on Hydraulic Power Plants in the first edition. This will doubtless be regretted by water-power engineers. Perhaps the editor might consider publication, in advance of a second edition, of a supplement in the form of a pamphlet on this subject.

It would be easy to criticise details of a book of this size, at a time when some of the developments described are still new and, perhaps, controversial. While it has clearly been the editor's aim to ensure concise treatment of each subject, he is aware of a certain amount of overlapping between individual chapters. This is all to the good where the same subject has been treated, by different contributors, in markedly different ways. No doubt the arrangement of the subject matter has to a large extent been influenced by the choice of the contributors who tend, quite naturally, to lay special stress on matters in which they themselves are most interested. The result has been a work both valuable and, in parts, intensely stimulating.

The publishers and printers have made a great effort to produce a volume whose printing and appearance is worthy of the great importance of the contents, and the book will be an outstanding addition to the library of the practising engineer. P.O.W.

Galion Motor Graders

Two new models of motor graders are now in course of production by Galion (Great Britain) Limited to designs that have already been developed and proved in the United States. Both models are similar in design and construction and are powered by Leyland diesel engines, the Galion Model 104 having an 80 h.p. engine, and the Model 118, for extra heavy duty, one of 100 h.p.

Full hydraulic control is applied to all movements of the mouldboard, scarifier and leaning wheels, and the steering is hydraulically boosted, so that the operator is entirely relieved of fatiguing control movements. The blade range with the 12 ft. mouldboard is 97 in. sideshift, 90° vertical and 360° horizontal rotation. A hydraulic sideshift is available as special equipment, enabling the operator to obtain additional reach without having to set the mouldboard manually before commencing work.

A constant-mesh gearbox provides six forward and two reverse speeds, the high forward and reverse speeds being 21·5 and 10 m.p.h. respectively.

Attention has been paid to securing a good power/weight ratio and properly distributed weight. Extra-large traction tyres conduce to greater flotation and stability, and to minimise spares similar tyres are fitted to both front and rear wheels.

The Galion graders are distributed in the United Kingdom and certain overseas territories by Jack Olding and Co. Ltd., Hatfield, Herts.

Measuring Movement in Buildings

There are many circumstances in which it is desirable to keep a watch on possible movement in a building. An instance was recently brought to our

Galion Model 118 extra-heavy-duty motor grader in action

notice in which a settlement in a hydro station threw the main generating sets out of alignment; buildings on made-up ground and particularly in areas subject to mining subsidence are liable to movement which may damage or even destroy the structure; and in cases where old or historic buildings must be preserved, a constant check on structural movements must be maintained.

A system which is claimed to detect structural movements with great accuracy and to be easily handled by one man has been devised, and patent protection applied for, by Mr. C. F. Ward, Managing Director of Ward & Paterson Limited, 7 Welbeck Street, London, W.1, who have for many years specialised in the renovation and reconstruction of old buildings, particularly churches, and who built the American Embassy in London.

Four small metal plates are let into the floor at the corners of the building, each carrying a cheese-headed screw over which the loop of the steel tape is hooked when measurements are to be taken, and which can be screwed flush when not required. These screws form the base from which all readings are taken, and their relative positions are determined by measurements taken along the sides and diagonally.

These measurements enable any subsequent relative movement at the corners to be determined precisely. Movement at any other point can be watched by a plumb line which is installed permanently at that point and when not in use is weighted with a small trailer plummet and hoisted out of the way by a wire and pulley. The unusual feature is the device by which the position of the plumb bob is registered accurately by a mark on the floor, or more conveniently on a piece of tracing paper located on a floor plate. A metal box has been designed which is levelled by set screws and has a notch in its upper face whereby it can be located accurately on the plumb line on both axes. A fitting on the lower face of the box then provides for a cross to be drawn precisely under the point of the bob. This is claimed to be so accurate that subsequent measurements will show the amount and direction of any movement with a precision up to the limit of visual discrimination. A further fitting enables the plumb line to be locked so that direct measurements can be taken to walls, pillars or stanchions where bulging or movement is suspected. The plumbing wire is 1/126th in. in diameter so that accurate measurements can be taken.

Incidentally, the box serves a useful secondary purpose in protecting the plumb bob from movement by draughts.

Any number of plumb lines can be installed according to the particular needs, but only one box is needed. This is made in light metal and folds up into a case for convenient carrying. The whole of the gear, in fact, is devised so that one man can check the measurements at any time. The system can also be adapted to buildings in which the floor is obstructed by fixtures or machinery.

Abstracts from the World Technical Press

Machkund Development

This is the most important hydro-electric project now under execution under the five-year plan of development launched by the Madras State at the end of the last war. The first stage of this scheme provides for an installed generating capacity of 51,000 kW, to be increased ultimately to 100,000 kW.

The Jalaput dam, 1,310 ft. long by 158 ft. above the deepest foundation, to be built across the Machkund two miles below its confluence with the Patala, will create a storage reservoir of 25,650 million cu. ft.; four 8 ft. 6 in. diameter steel pipes, of which two will discharge power water into the river and two will develop power at a future date at the dam site, will be fixed in the dam.

A diversion dam, 17 miles lower down the river and about 1½ miles above the 550 ft. jump of the Duduma Falls, will provide a regulation and balancing storage of 389 million cu. ft. From the intake works at the diversion dam water will flow to the turbines through a concrete-lined channel and a free-flow tunnel 4,060 and 4,010 ft. long respectively, the latter leading to a tunnel pond forebay from which a 3,000 ft. pressure tunnel will connect through two steel pipes and two three-branch manifolds with the six penstocks. These penstocks, each 1,660 ft. in length, consist of steel pipes varying in diameter between 57 and 63 in., and in thickness between 11 and 37 mm.

The power house, 290 ft. long, 62 ft. wide and 65 ft. high from the generator floor level, will have an initial equipment of three vertical-shaft reaction turbines

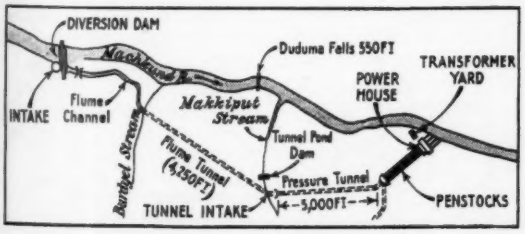


Fig. 1. Site plan showing the civil and hydraulic works

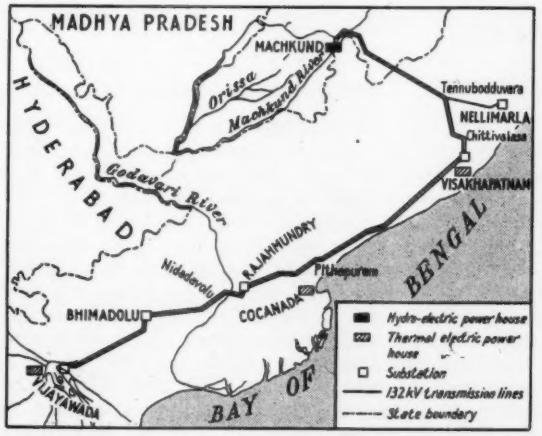


Fig. 2. Transmission system of the Machkund project

each rated at 25,000 h.p. and coupled to a 17,000 kW 11 kV 600 r.p.m. generator. In the outdoor substation, close to the power house, there will be ten single-phase transformers stepping up the voltage to 132 kV.

A particularly interesting feature of the transmission system serving the Madras State (285 miles of 132 kV double-circuit lines) is the crossing of the Godavari near Rajahmundry by means of 18 towers, inclusive of terminals located outside the flood bank of the river. To check scouring, the ten towers standing right on the river bed will be erected on well foundations. In addition to power conductors all towers will carry a pair of "Hardex" earth wires for the telephone system, the armouring of the cable acting as earth conductor for the four-mile river crossing.

Despite scarcity of labour, work on this scheme is progressing rapidly, and the first-stage installation is expected to be ready for service before the end of 1953. (K. R. Radhakrishnan and V. P. Appadurai, *Power Engineer*, Simla, Vol. 2, No. 1, January 1952, p. 2, 8 pp., 10 ff.)

Sacramento River Project

A U.S. Bureau of Reclamation report just completed is one further step toward federal development of power and irrigation facilities in northern Sacramento Valley. The new work, to be added to the nearly completed Central Valley project, is separate and distinct from the recent billion-dollar proposals made by the State of California for a state-wide scheme which covers part of the very same area.

The main features of the scheme, which will provide additional water for 200,000 acres in Tehama, Glenn, Colusa and Butte counties, include the 120 mile main Tehama-Colusa canal from Red Bluff to southern Colusa county, two smaller canals for local needs, a diversion dam on the Sacramento river south of Red Bluff, and a 24,000 kW power plant on the river at Mooney Island between Red Bluff and Gerber.

Under full development, 665,000 acre-ft. of water will be diverted from the river annually, 35 per cent. being returned to the river after irrigation use. The power plant will utilise the 32 ft. drop from the main canal to the river level at Mooney Island. Power generated will be used for canal pumping plants and the remainder sold commercially. (*Engineering News-Record*, Vol. 148, No. 4, Jan. 24, 1952, p. 33, 3rd column.)

The Storage Lakes of the Alps

The first instalment of this survey, which dealt with the storage lakes of the eastern ranges of the Alps, either in operation or in course of development, was reviewed in our issue of September, 1951, page 358. The second and final article is devoted to the Western Alps, taking as previously a borderline running southward from the Lake of Constance through the Rhine valley and the Splügen Pass between Lombardy and Grisons to the Lake of Como. As in the first article the main characteristics of the lakes surveyed are summarised in a table accompanied by a map with reference numbers. The table divides the lakes into three geographical regions in relation to the main ridge, viz., north (28 lakes, all in Switzerland), west (24, all in France), and south (1 lake in France, 35 in Italy, 8 in Switzerland). Ten lakes in the west, and one in the south region, are in territories ceded to France by Italy after the war in 1946.

The average altitude of the storage lakes of the Western Alms is 1,500 m. above sea level, i.e. about 240 m. higher than in the eastern ranges; the number of lakes now in operation or under development is the same in both ranges, viz. 98, with an aggregate useful capacity of 2,518 million cubic metres in the western ranges against 2,031 in the eastern ranges. The figures for the Grande Dixence scheme are not included in this survey since it is still at its initial stage of development and its completion will take many years. Schemes of development contemplated for the future are dealt with in a separate section.

In its conclusion the author assesses the aggregate volume of concrete and masonry work required by the dam structures in conjunction with the storage lakes of the Alps—Grande Dixence excepted—at 20·7 million cubic metres, i.e., eight times the volume of the Great Pyramid. The volume of water stored per cubic metre of concrete or masonry used in the dams is 198 cu. m. for the western, and 252 cu. m. for the eastern ranges. Referred to the energy available, the figures are 440 kWh per cu. m. for the eastern, and 470 kWh per cu. m. for the western ranges. This very small difference of 30 kWh per cu. m. in favour of the western ranges is rather surprising if we take into account the greater heads—natural or installed—prevailing in the French plants. (Dipl. Ing. Harald Link, Innsbruck, *Wasser- und Energiewirtschaft*, No. 1—2, Vol. 44, Jan.-Feb. 1952, p. 1, 28 pp., 27 ff.)

The Passy Scheme (Arve Development)

Downstream from Chamonix, the Arbe, a left-bank tributary of the Rhone draining part of the Mont Blanc and Aiguilles Rouges massifs, forms a fairly sharp loop with a relatively steep gradient. What Electricité de France had in mind at Passy was to concentrate at a single spot the utilisation of the energy available, previously divided among several rather old plants.

Beginning upstream the Passy scheme comprises the following works:—

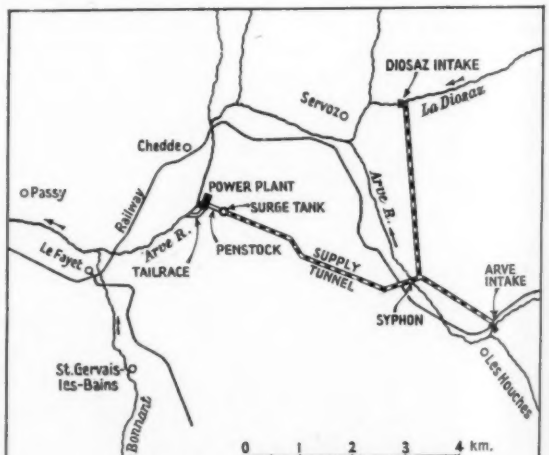


Fig. 1. Layout of the Passy scheme

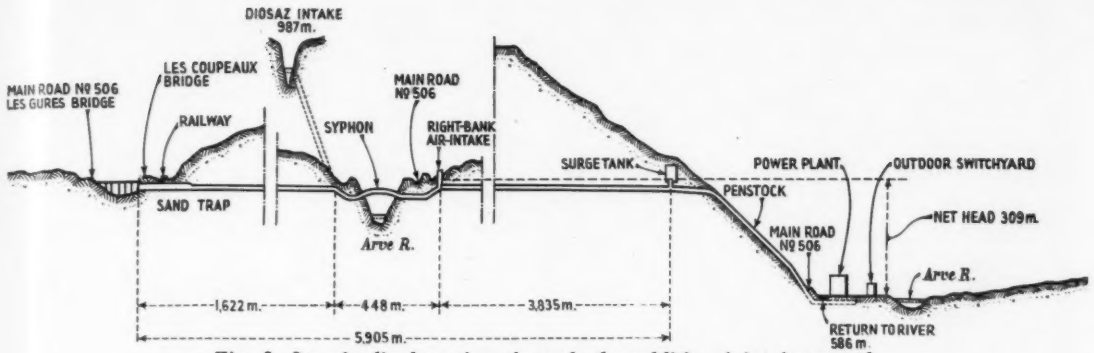


Fig. 2. Longitudinal section through the additional intake tunnel

(1). A main intake on the Arve, at the downstream end of the Houches plain, with a weir consisting of a gravel pass, and two flood-control sluices for a discharge of 385 cu. m. per second. The sluices are provided with sector-gates 6 m. in height, and automatic shutters at the top.

(2). A pressure tunnel about 6 km. in length, varying in cross-section between 10 and 17 sq. m., whose continuity across the Arve is ensured by a syphon 450 m. in total length, with a span of 72 m. across the gorge, and consisting of steel sections 3 m. in diameter.

(3). An underground surge tank and a penstock. The driving of this non-overflowing surge tank met with serious difficulties, partly because of the lack of adequate space for working floors, partly owing to the very poor quality of the ground, which entailed the use of protective wiring in almost all excavations; this tank consists of a shaft 44 m. in height, two expansion chambers and an opening chamber. The single-line penstock, 880 m. long, consists of special reinforced pipes 2·40 m. in diameter, with a butterfly-type control valve at the top, and, at the bottom, a chamber with four branches each feeding one of the four generating sets of the plant.

(4). The powerhouse, equipped with four generating sets consisting each of two 15,750 h.p. double-jet Pelton wheels, running at 428 r.p.m., under a net head of 355 m., and of a 27,000 kVA 10,000 V alternator. The extensive outdoor switchyard is set up on a floor covering part of the tailrace, which, after a short open-air stretch, runs into the Arve, a short distance upstream from Le Fayet.

The large transformer substation contains the following units: three 10/150 kV, 27,000 kVA, and three 10/45 kV units for 27,000, 40,000 and 7,000 kVA respectively.

The main advantage of this installation is that it adds at relatively low cost, 310 million kWh per annum to the 52 millions generated by the old plants, and owing to the glacial character of its catchment area, it has its highest discharge in August and September, precisely at the time the low-head plants and the Alpine and Pyrenean plants depending upon snowfall have, as a rule, an inadequate supply of water.

Except for a few momentary difficulties in boring operations, work on this scheme, which started at the beginning of 1948, progressed at a fairly quick rate, so that the fourth generating set is about to be put into operation.

An additional intake tunnel, 4 km in length, shown in Fig. 2, between the railway line and the syphon, is to be driven in the near future, and will convey the water of the Diosaz—a right-bank tributary of the Arve—to the main supply tunnel just upstream of the siphon. (*La Houille Blanche*, Vol. VI, Pictorial Supplement to No. 6, Nov.-Dec. 1951, p. 869, 12 pp., 22 ff.)

Designing Heavy High-Voltage Transformers

This paper is a comparative study of the various types of heavy high-voltage transformers. The author deals first with the magnetic circuits (core-type and shell-type transformers) in single-phase and three-phase transformers, and then with the types of winding. The various transformer designs are reviewed, more particularly the core-type transformer with concentric winding, and the shell-type transformer with alternate winding; the results of this investigation are given in a table, from which the author concluded that, material being equal in quality and the safety factors being within comparable range, the core-type transformer with concentric winding is to be preferred to the shell type with alternate winding in single-phase as well as three-phase designs. (M. A. Pichon, *Bulletin de la Société Française des Electriciens*, Series 7 (Vol. II), No. 14, February 1952, p. 69, 16 pp., 17 ff.)

Hydro-Generators — Rugged Individualists

Restricting factors exclude hydraulic-turbine-driven generators from the standardisation trend mutually accepted by both manufacturers and users of steam-driven turbo-generators. The required characteristics of water-driven generators are determined by the hydraulic turbine, while the characteristics of the turbine itself are in turn dictated by the hydraulic conditions of each individual installation. Since the flow of water and the height of dams are incapable of standardisation, it is frequently necessary to use non-standard ratings for hydro-electric units.

Speed is another vital consideration that sets steam turbo-generators and water-driven generators apart. Whereas steam turbines operate at either 3,600 or possibly 1,800 r.p.m. for 60 cycle supply, hydraulic turbines are essentially low-speed machines ranging from 50 to 1,200 r.p.m. so that the water-driven

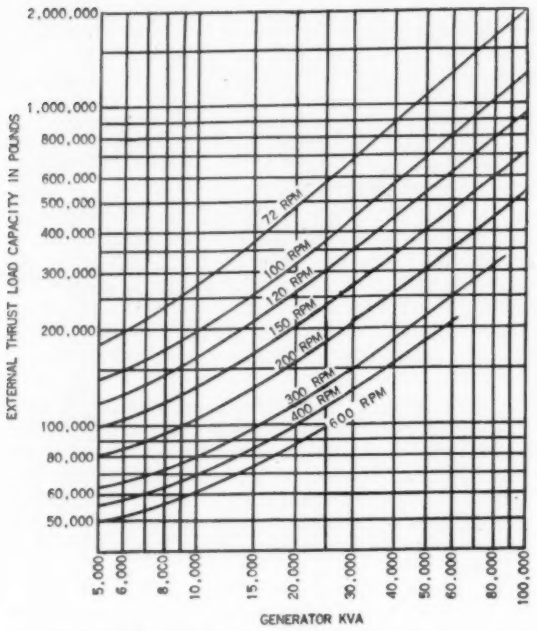


Fig. 1. Approximate external thrust loads for vertical 60-cycle generators

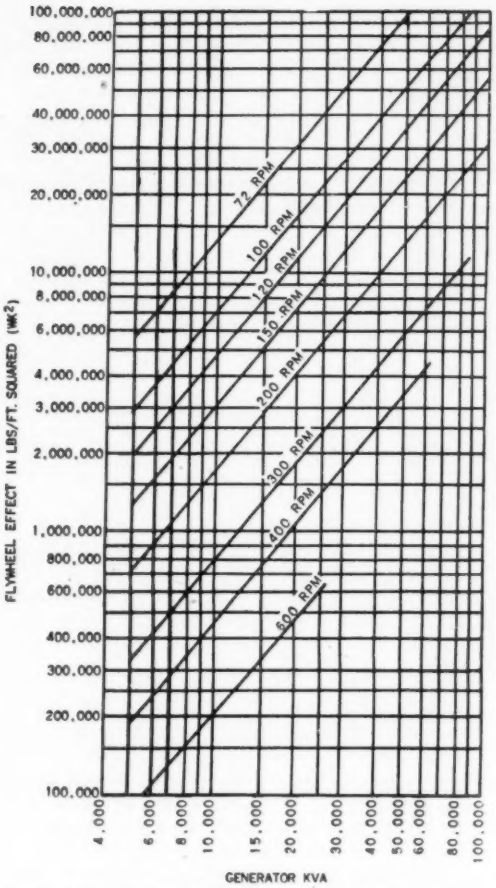


Fig. 2. Average flywheel effects for hydro-generators

generator must be built for a range of widely varying speeds.

Hydraulic thrust load also affects the design of water-driven generators in a high degree, especially in vertical-shaft propeller and reaction turbines. The loading imposed upon the generator thrust bearing by the hydraulic turbine is an essential factor in the design of a vertical generator. Fig. 1 shows the approximate external thrust loads that are considered normal for vertical 60-cycle generators; any additional load will increase generator design requirements, and this also means a higher initial cost.

A further factor to the detriment of the water-driven generator is the complication of speed control resulting from overspeed. With a maximum flow of water through the turbine and no load on the generator, speed increases of as much as 175 to 260 per cent. of rated speed will result. Since the centrifugal forces set up in the generator rotor vary with the square of the speed, rotor construction must obviously be affected by the runaway speed of the turbine. In steam turbines sudden losses of load on the generator are efficiently met by governor action, and besides, the overspeed trip will instantly shut off the steam supply. Steam is, of course, compressible but water is not, and any attempt to shut off the flow of water to a hydraulic turbine suddenly would spell disaster.

A third variable which may require evaluation is the amount of wk^2 (flywheel effect) that must be incorporated in the generator rotor. The importance of this factor is less today, since hydro-electric plants or generating units are now usually operated as part of a large system, and wk^2 above normal is, as a rule, of no particular value for fluctuating load conditions. The average flywheel effects of hydro-generators shown in Fig. 2 are adequate for most installations. Greater than normal wk^2 will increase generator cost.

After a brief survey of the three usual types of hydraulic turbines, the author deals with the characteristics of the vertical and horizontal-shaft setting in hydraulic turbines. Until recently the horizontal shaft was almost a monopoly of the impulse turbine; the use of multiple jets reduces the size of each jet with resulting smaller buckets, and also permits a higher speed, with decreased turbine and generator costs. Following model tests, the number of vertical-shaft impulse turbines is now on the increase.

Because of all these variable characteristics, each hydro-generator must obviously be designed to meet the requirements of the individual installation. It is very seldom that a generator designed for one plant can be transferred to another installation without major redesign of some or all of the principal parts of the generator, even though kVA rating and speed happen to be the same in both cases. (H. H. Roth, *Allis-Chalmers Electrical Review*, Vol. XVI, No. 4, Fourth Quarter 1951, p. 22, 5 pp., 7 ff.)

Shawinigan Progress. Work being carried out by The Shawinigan Engineering Company on the project to divert the Megiscane and Susie Rivers into the Gouin Reservoir to increase the flow of the St. Maurice river, is proceeding according to schedule, which provides for completion in October 1952.

C.P. 119

AIR POWER FOR PIPELINES

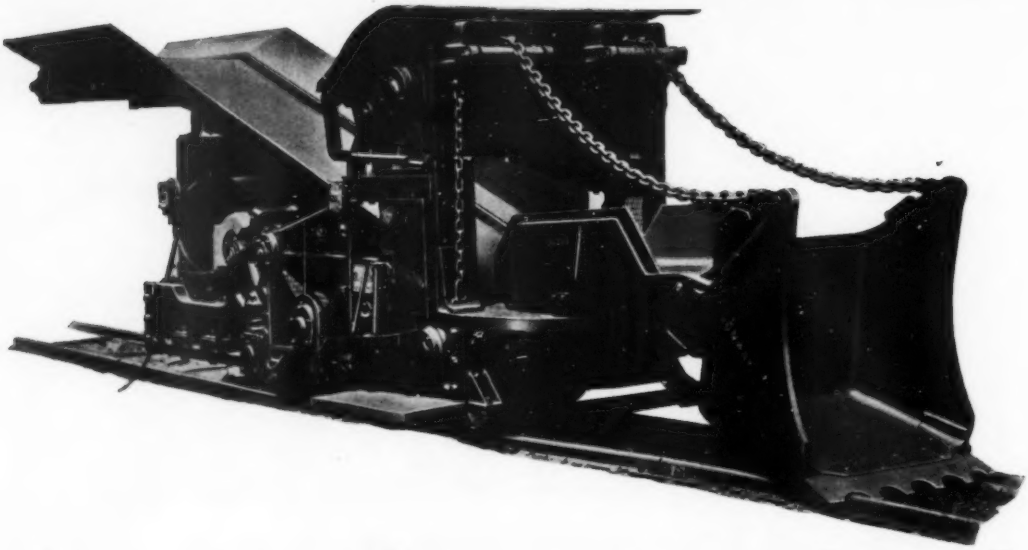
The multitude of construction jobs in the petroleum industry make terrific calls upon pneumatic plant. Here, indeed, is a challenge to the ruggedness, efficiency and reliability of CP equipment. Planned and engineered with imagination and experience, it meets the severest tests imposed by jobs of this kind, whether for preparation of sites and pipe-line trenches, or for workshops and maintenance. Wherever pneumatic power is required, CP equipment will do the job well at the lowest cost in the long run. Surely adequate reasons to . . .

CALL IN CONSOLIDATED

CONSOLIDATED PNEUMATIC TOOL CO. LTD. - LONDON & FRASERBURGH

Offices at Glasgow · Newcastle · Manchester · Birmingham · Leeds · Bridgend · Belfast · Dublin · Johannesburg Bombay · Melbourne · Paris · Rotterdam · Brussels · Milan · and principal cities throughout the world

British Conway Loaders



take another step ahead!

WITH THREE NEW AND EXCLUSIVE IMPROVEMENTS

Practical experience gained in the world's toughest tunnelling projects has inspired important improvements in the British Conway Loader. These exclusive modifications, detailed on the right, still further enhance Conway leadership.

Tunnelling with the Conway is now even more efficient, even more trouble free, even more economical.

The new Superlift Bucket with its manganese steel lip will load the hardest rock without risk of damage, and because provision has now been made for operating the Conway from either side, it is actually easier for the one man to operate the machine, easier for him to tram, root, swing or hoist.

Working with the Conway clutch operated endless belt conveyor, the loader will keep trucks or conveyors moving at the average rate of over 200 tons an hour. Let us give you a demonstration. ***Brochure free on request.***

1. SUPERLIFT BUCKET
(Provisional patent No. 8304/52)

Embodying a simple, robust, radial-link attachment for the Hoisting Chains, whereby the force available for the initial heave of the bucket upward through the muck-pile is greatly increased.

2. SELF ALIGNING BEARINGS

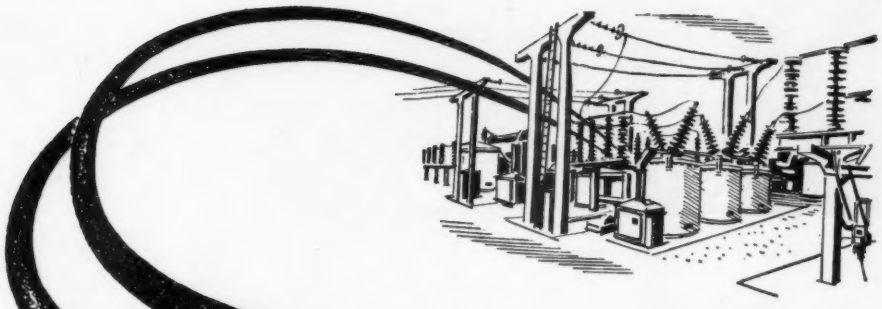
Full "swivelling" type, carrying the Propellor Hoist and Conveyor driving shafts, raising transmission efficiency and reducing wear to a minimum.

3. HYDRAULIC OPERATIONAL CONTROL
(Provisional patent No. 8305/52)

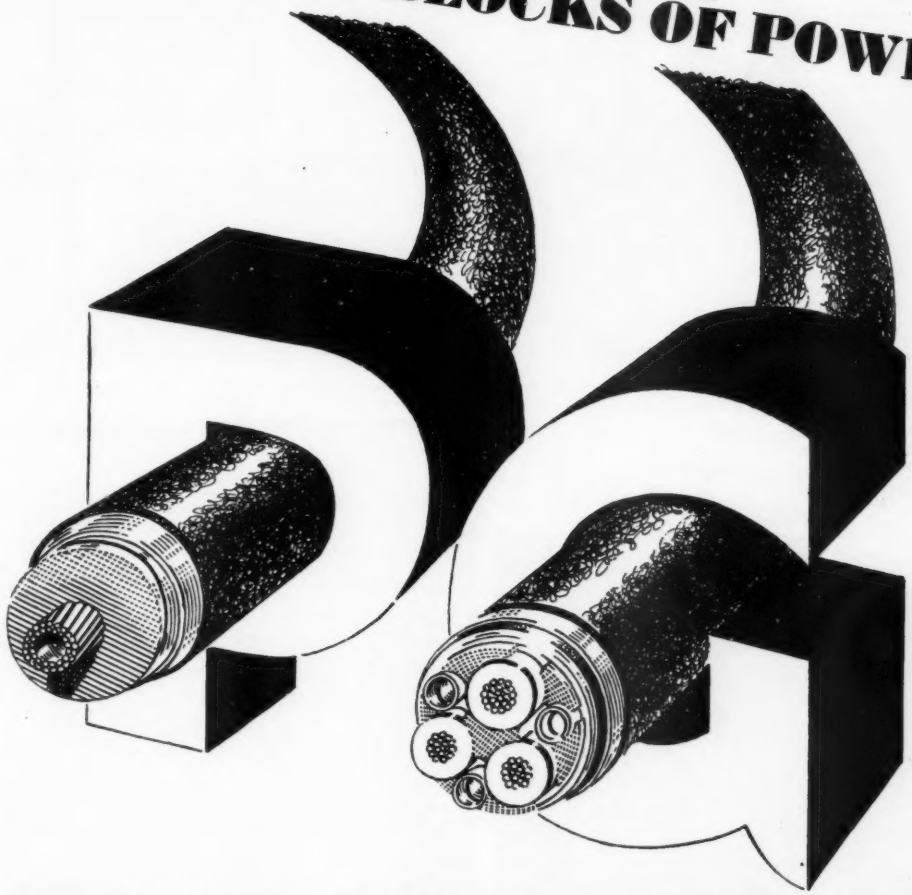
Self-contained oil-hydraulic system embodying independently controlled Ram actuated Clutch engagement, arranged to permit "either side" operation. Clutch slip and over-heating is eliminated so raising effective performance without fatigue to the operator.

BRITISH CONWAY LOADERS LTD., 3 CASTLE STREET, CARDIFF · TELEPHONE CARDIFF 29246/7/8 · TELEGRAMS: POWERSHOVL, CARDIFF

A Print for Industry Ltd. Advertisement



FOR LARGE BLOCKS OF POWER



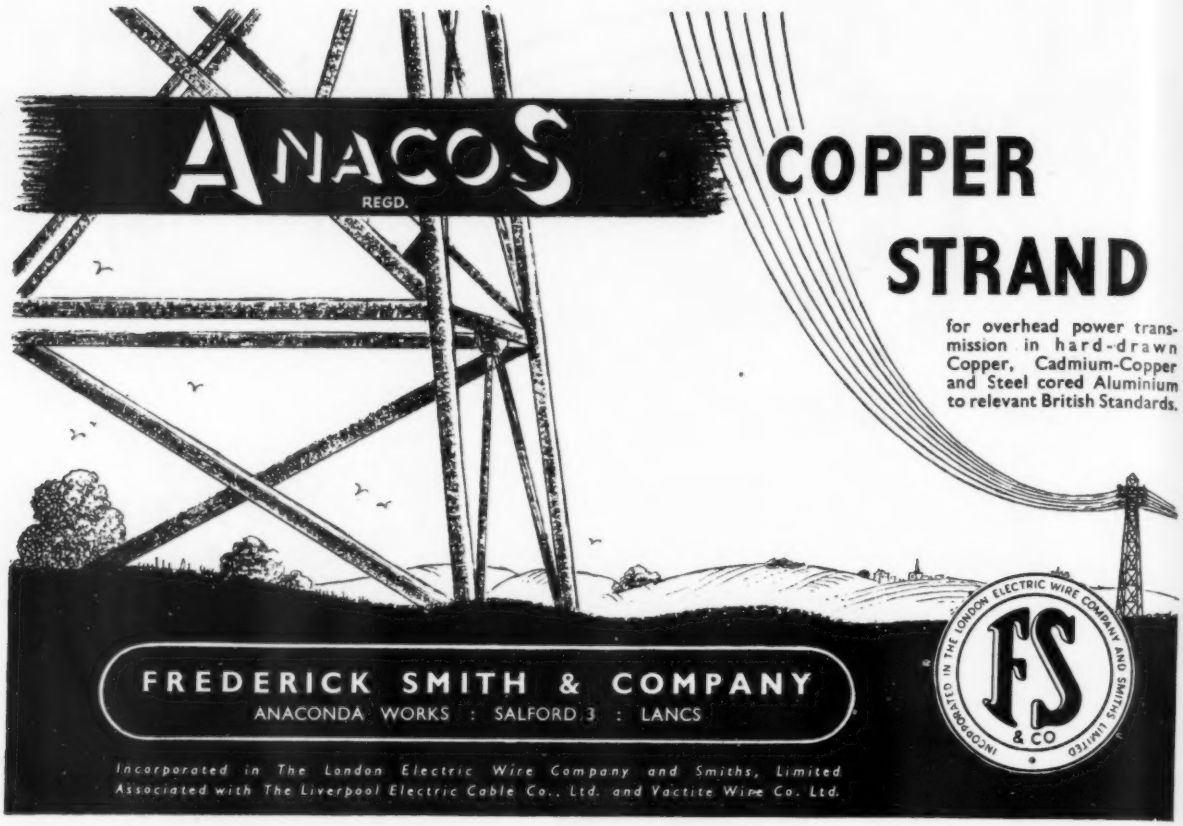
OIL-FILLED SUPER TENSION CABLES

33 kV to 330 kV

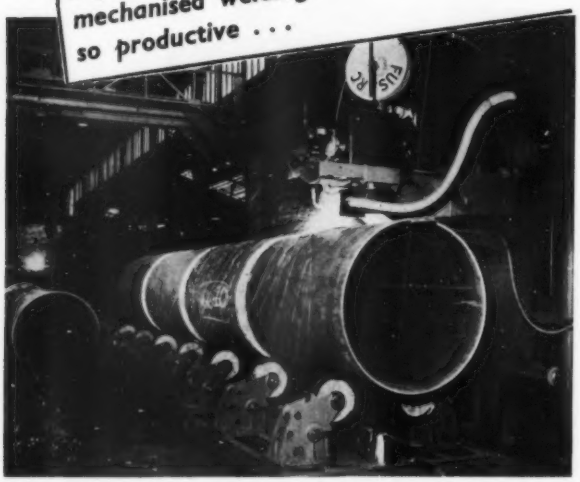
PIRELLI-GENERAL

MANUFACTURERS OF EVERY KIND OF ELECTRIC CABLE

PIRELLI-GENERAL CABLE WORKS LIMITED, SOUTHAMPTON
(Associated Company of the General Electric Company Limited)


ANACOS
REGD.
COPPER
STRAND
for overhead power transmission in hard-drawn Copper, Cadmium-Copper and Steel cored Aluminium to relevant British Standards.
FREDERICK SMITH & COMPANY
ANACONDA WORKS : SALFORD 3 : LANCS
Incorporated in The London Electric Wire Company and Smiths, Limited
Associated with The Liverpool Electric Cable Co., Ltd. and Yactite Wire Co. Ltd.
INCORPORATED IN THE LONDON ELECTRIC WIRE COMPANY AND SMITHS LIMITED
FS
& CO

IT IS FUSARC-PLANNED EQUIPMENT which makes mechanised welding so productive . . .



Photograph by courtesy of Alex. Findlay & Co. Ltd., Parkneuk Works, Motherwell

PIPE LINES are only one example of a production welding job *planned* by Fusarc. There are scores of other examples in a wide field of work, illustrated in Fusarc Production News Sheets, free copies of which will be sent regularly on request.

FUSARC
MECHANISED WELDING

FUSARC LTD., TEAM VALLEY, GATESHEAD 11 CO. DURHAM

Specify

MICHELL
AND MAKE SURE OF YOUR
BEARINGS

THEY 'SET THE COURSE' FOR ENDURING RELIABILITY

for Hydro Electrical Installations, Turbine Thrusts, Pedestal Bearings, Motors, Generators, Pumps (Vertical and Horizontal), Fans, Paper-Making and Extruding Machines, etc.

MICHELL BEARINGS

SOUTH BENWELL NEWCASTLE upon TYNE

Telegrams: MICHBEARO
Telephone: 34279

OFFICINE ELETTROMECCANICHE

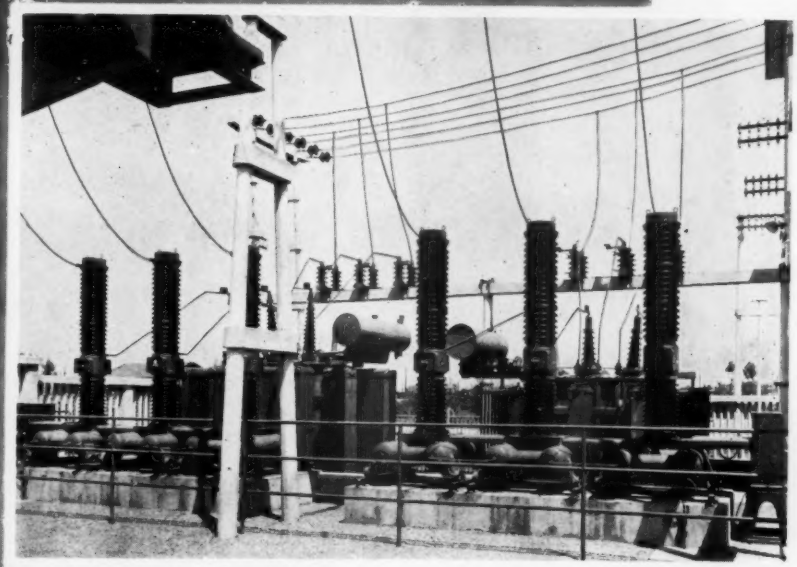
SCARPA & MAGNANO

SAVONA (ITALY)
Via Fiume, 2
CAP. L. 200,000,000
OFFICE IN MILANO
Via Revere, 14
Telegrams : Scarpamagnano

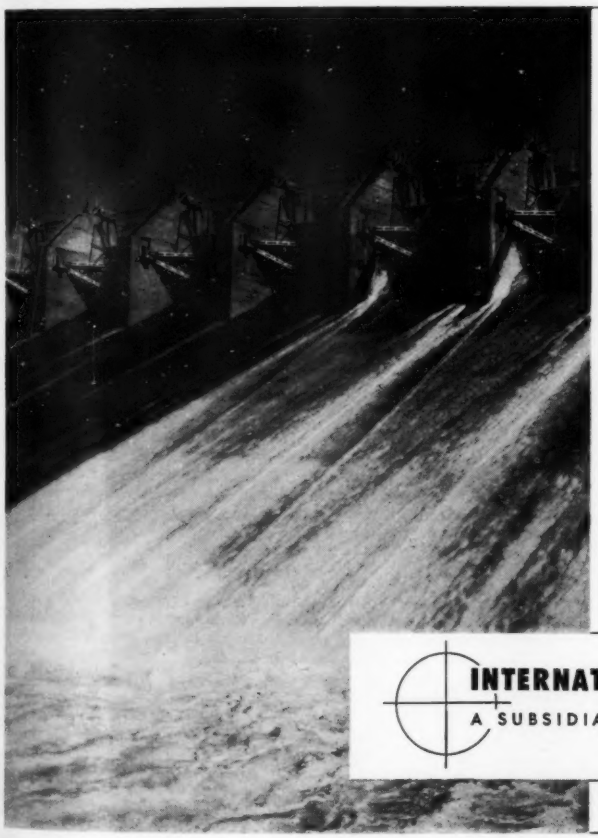
Switchgear:

CIRCUIT BREAKERS
ISOLATING SWITCHES
INSTRUMENT TRANSFORMERS
SWITCHBOARDS, ETC.

FOR BOTH INDOOR AND OUTDOOR SERVICE . . .
FROM 10 UP TO 220 KV



Compressed-air Circuit Breakers, type ACR/90, at the Novi Ligure sub-station of the Societa Cieli



RIVER TAMERS

The engineering design and construction of hydro-electric and irrigation projects have been the primary task of the Morrison-Knudsen oganization for more than 40 years. This long and specialized experience has successfully utilized the water resources of some of the world's mightiest rivers.

Notable among the river taming projects designed and built by the MK family and their associates are the following:

DESIGN PROJECTS:

Bhakra Dam & Power Plants — *India*
Seyhan River Dam & Power Plant — *Turkey*
Hirakud Dam & Navigation Locks — *India*

DESIGN AND CONSTRUCTION PROJECTS:

Gal Oya Dam & Power Plant — *Ceylon*
Kajakai Dam & Reservoir — *Afghanistan*
Arghandab Dam — *Afghanistan*

The MK organization has also participated in joint ventures for the construction of these major projects in the U. S. A.:

HOOVER DAM
GRAND COULEE DAM
HUNGRY HORSE DAM
ANDERSON RANCH DAM
GARRISON DAM

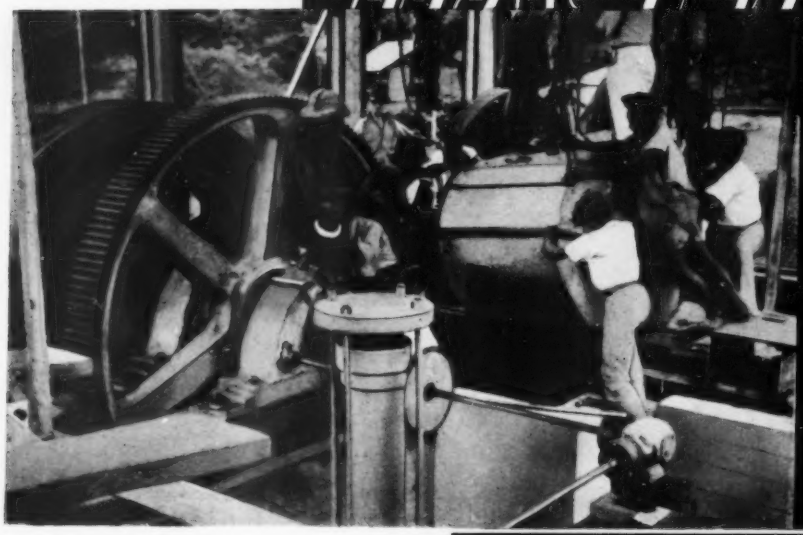
For further information, write to

INTERNATIONAL ENGINEERING COMPANY, INC.
A SUBSIDIARY OF MORRISON-KNUDSEN COMPANY, INC.
74 NEW MONTGOMERY ST., SAN FRANCISCO 5, CALIF.

C. J. Strike Dam, Idaho, U. S. A.

EFFICIENT

HAULAGE



Hydro-Electrification Scheme—Ceylon

Installation of Haulage Gear at Norton Bridge

M. B. WILD & Co LTD NECHELLS BIRMINGHAM 7

Telephone EAST 2041-7 Telegrams & Cables HAULING BIRMINGHAM 7

THE RAILWAY GAZETTE.
A journal of Railway Management, Engineering, Operation, and Railway News. It covers every phase of railway activity. It is truly said of this journal that it is "Read Wherever there are Railways." *Yearly £4 10s. post free. Weekly 2s.*

DIESEL RAILWAY TRACTION.
A monthly review of world-wide developments in diesel-engine design, practice and maintenance and diesel railway traction operation. *Yearly 30s. post free. Monthly 2s. 6d.*

SHIPBUILDING AND SHIPPING RECORD.
The only publication with direct appeal to both shipowner and shipbuilder. Its world-wide news organisation and technical articles and drawings put it in the forefront of shipping periodicals. *Yearly £4 10s. post free. Weekly 2s.*

POWER AND WORKS ENGINEERING.
Specifically concerned with the effectiveness and economy of factory services, including steam raising, power generation and application, and all engineering plant problems. *Yearly 35s. post free. Monthly 2s. 6d.*

COLLIERY ENGINEERING.
A practical journal dealing with all aspects of coal production; every branch of coal mining technology is reviewed in detail and special attention is given to mechanisation and labour-saving machinery. *Yearly 35s. post free. Monthly 2s. 6d.*

COKE AND GAS.
A technical journal dealing with the scientific and technical problems involved in the production of coke and gas in coke ovens and gasworks, and the industrial uses of these fuels. *Yearly 30s. post free. Monthly 2s. 6d.*

THE RAILWAY MAGAZINE.
A popular magazine containing illustrated articles on Railways and Locomotives Published Monthly. *Prepaid Annual Subscription 32s. Single copies 2s. 6d.*

NEW COMMONWEALTH.
Describes and illustrates significant developments in production, trade, transportation and related spheres in all countries of the Commonwealth, and provides a unique service of economic information from 50 countries with a total population of 560 millions. *Prepaid Annual Subscription 50s. Fortnightly 2s.*

THE INDUSTRIAL CHEMIST.
A technical journal devoted to the progress of applied chemistry and chemical engineering. It is of vital importance to the chemical manufacturer and all who employ chemical processes in their productive operations. *Yearly 35s. post free. Monthly 2s. 6d.*

BUILDING.
A journal for practising and salaried architects, building contractors, designers and specialists. It deals with the planning, design, construction and the administration of modern building work. *Yearly 35s. post free. Monthly 2s. 6d.*

WOOD.
"Wood" is the only magazine of its kind. Primarily concerned with the use of wood, it includes articles on trees and timbers, design and construction in all decorative and practical wood usage, machines and machine practice, and trends in world supply. *Yearly 35s. post free. Monthly 2s. 6d.*

FOOD.
A journal devoted to the manufacture, packing and marketing of processed foodstuffs, and of the utmost value to firms supplying plant, equipment or materials for the food industry. *Yearly 35s. post free. Monthly 2s. 6d.*

WATER POWER.
A technical journal devoted to the study of all aspects of Hydro-Electric Development. Published monthly. *Yearly 35s. post free. Monthly 2s. 6d.*

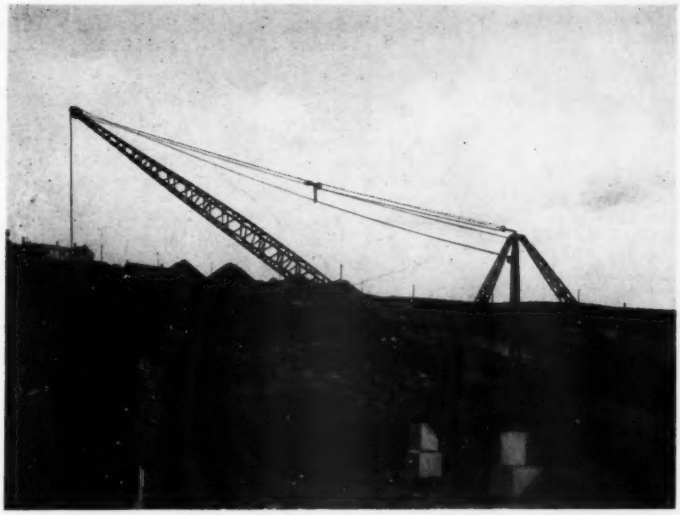
All above published at **33, Tothill Street, Westminster, London, S.W.1**

ANDERSON DERRICK CRANES

OUTSTANDING FEATURES:

- PROGRESSIVE DESIGN TO B.S.S. 327/1
- EXCLUSIVE "UNIT" GEARING
- SUPERIOR VISIBILITY
- HIGH SPEED OPERATION
- RELIABILITY & ECONOMY
- INTERCHANGEABLE SPARES

LONDON OFFICE:
Finsbury Pavement House
120 Moorgate, E.C.2
Tel: MONarch 4629



5-ton Electric Derrick Crane x 130 ft. Jib

Phone:
CARNOUSTIE
2214-5

THE ANDERSON-GRICE CO. LTD.
TAYMOUTH ENGINEERING WORKS - CARNOUSTIE - SCOTLAND

Grams:
DIAMOND
CARNOUSTIE

BPC

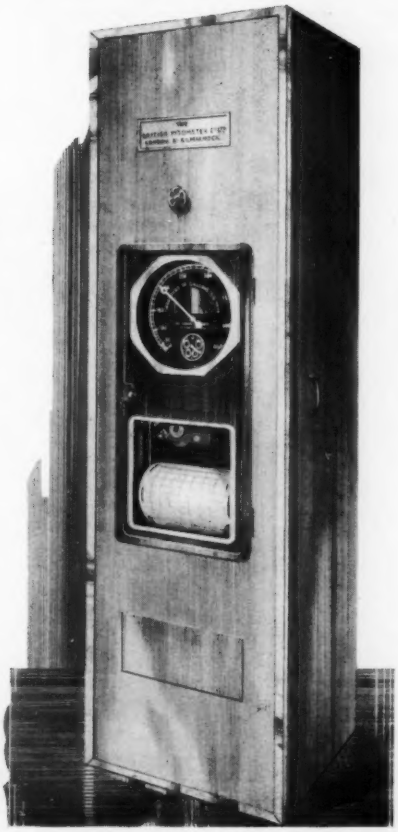
Measuring Equipment
FOR HYDRO-ELECTRIC PLANTS

WATER FLOW
in Tunnels, Pipe Lines and at Turbines.

WATER LEVEL
at Dams and in Surge Shafts for all depths and conditions.

PRESSURE RECORDERS, *ETC.*
backed by over 20 years' experience in this specialised field, can be supplied for local or remote operation.

The illustration shows the type of Flow Meters now being made for the North of Scotland Hydro-electric Board.



The British Pitometer Co.Ltd
(ASSOCIATED WITH GLENFIELD & KENNEDY, LTD.)
105, PARK STREET, LONDON, W.1.

INDEX TO ADVERTISEMENTS

A
Allmanna Svenska Electriska Aktiebolaget ... ... —
Anderson-Grice Co. Ltd. 41
Armfield Hydraulic Engineering Co. Ltd., The ... ... —
Arrol, Sir Wm. & Co. Ltd. ... ... —
Ateliers de Constructions Electriques de Charleroi 19
Atlas Diesel Co. Ltd. ... ... —

B
Balfour, Beatty & Co. Ltd. ... ... —
Bell, Theodore, Ltd. ... ... —
Billington & Newton Ltd. 12
Birkett, T. M. & Sons Ltd. 12
Blackwood Hodge 15
Blakeborough, J. & Sons Ltd. ... —
Blaw Knox Ltd. 6
Boving & Co. Ltd. 5
Brady, G. & Co. Ltd. 31
British Conway Loaders Ltd. ... 36
British Insulated Callender's Cables Ltd. 34
British Pitometer, The, Co. Ltd. ... 41
British Ropeway Engineering Co. Ltd. ... ... —
British Thomson-Houston Co. Ltd. 16
Brown, Boveri & Co. Ltd. 29
Bruce Peebles & Co. Ltd. 22
Butters Bros. & Co. Ltd. 4

C
Canadian Vickers Ltd. 17
Cementation Co. Ltd., The ... ... —
Ceretti & Tanfani Ropeway Co. Ltd. —
Charmilles Engineering Works Ltd. —
Christiani & Nielsen 11
Consolidated Pneumatic Tool Co. Ltd. 35
Costain, Richard, Ltd. ... ... —

D
De Roll, Louis, Iron Works Ltd. ... 3
Dominion Engineering Co. Ltd. ... 18

E
English Electric Co. Ltd. ... *Back Cover*
Escher Wyss Ltd. ... ... —

F
Fabbriche Riunite Cemento ... —
Ferguson Pailin Ltd. ... ... —
Ferranti Ltd. ... ... —
Ferrum (England) Ltd. 7
Fusarc Ltd. 38

G
Galileo Officine, di Battaglia Terme —
General Electric Co. Ltd. 10
Gilbert Gilkes & Gordon Ltd. ... 23
Glenfield & Kennedy Ltd. ... ... —

H
Hackbridge & Hewittic Electric Co. Ltd. ... ... —
Harland Engineering Co. Ltd., The 32
Henderson, John M. & Co. Ltd. ... 30
Henley's, W. T., Telegraph Works Co. Ltd. 25
Holman Bros. Ltd. ... *Inside Back Cover*

I
International Engineering Co., Inc. 39

K
Karlstads Mekaniska Werkstad ... —

L
Leffel, James & Company, The ... 28

M
Maschinenfabrik Augsburg-Nuernberg, A.G. ... ... —
Metropolitan-Vickers Electrical Co. Ltd. ... ... *Front Cover*
Michell Bearings 38
Millars' Machinery Co. Ltd. ... —
Morris, Herbert Ltd. ... ... —

N
Newport News Shipbuilding & Dry Dock Co. 26
Nuttall Edmund Sons & Co. (London) Ltd. ... ... —
Nydqvist & Holm Akt. 24

O
Oerlikon Engineering Company ... —
Onions & Sons (Levellers) Ltd. ... —

P
Pegson Ltd. 17
Pirelli-General Cable Works Ltd. ... 37

R
Ransomes & Rapier Ltd. ... ... —
Rawlplug Co. Ltd., The ... ... —
Reyrolle, A. & Co. Ltd. *Inside Front Cover*
Riva Costruzione Meccaniche ... —

S
Societa Anonima Elettrificazione ... 13
Salvi, A., & Company 7
Scarpa & Magnano 39
Smith, Fredk. & Co. 38
Smith, S. Morgan, Company ... 21
Smith, Thos. & Sons (Rodley) Ltd. —
Societa Forzate Condotte ... ... —
South Durham Steel & Iron Co. Ltd. —
Standard Telephones & Cables Ltd. —
Steatite & Porcelain Products Ltd. 20

T
Taylor, Tunnicliff & Co. Ltd. ... —
Tees Side Bridge & Engineering Works Ltd., The ... ... —
Transports Mecanises, S.A. 27

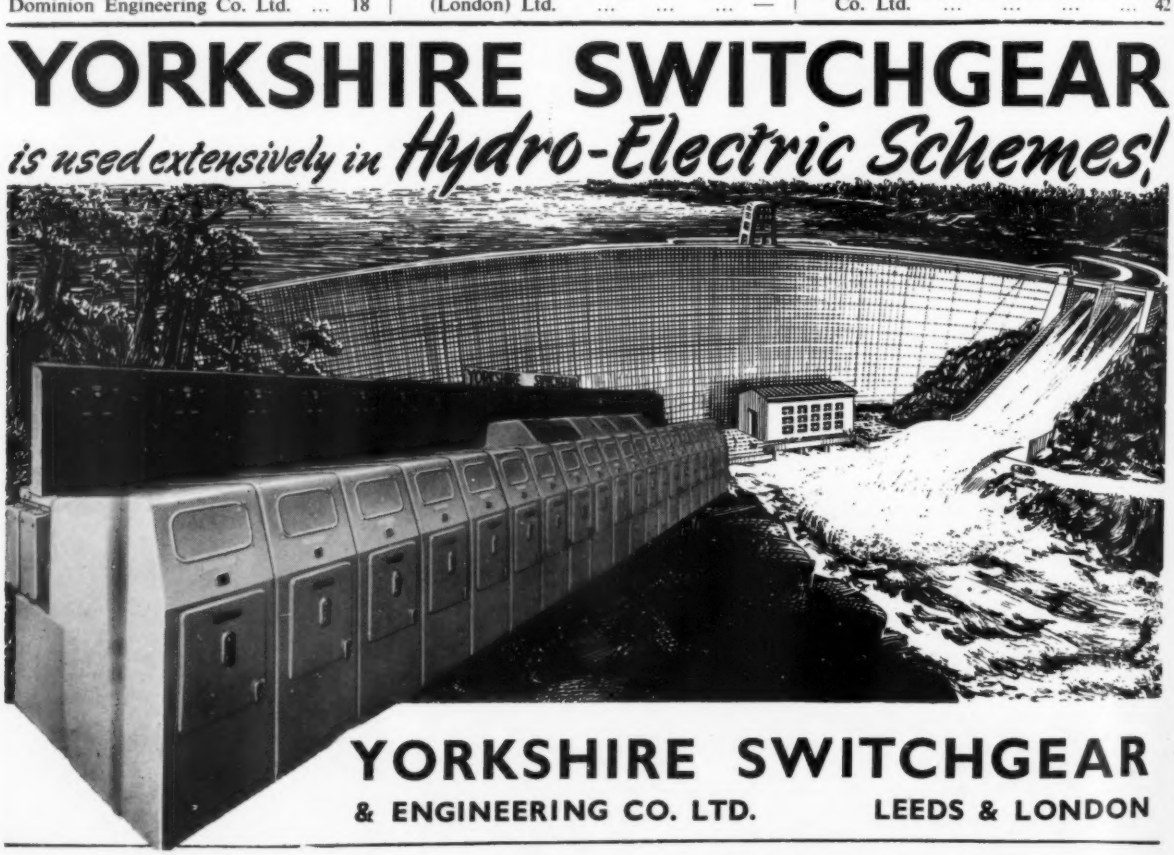
V
Vaughan Crane Co. Ltd. ... ... —
Vevey Engineering Works Ltd. ... —
Voith, J. M., G.m.b.H. 9

W
Wild, M. B. & Co. Ltd. 40
Wood, Hugh & Co. Ltd. 14

Y
Yorkshire Electric Transformer Co. Ltd. 8
Yorkshire Switchgear & Engineering Co. Ltd. 42

YORKSHIRE SWITCHGEAR

is used extensively in **Hydro-Electric Schemes!**



YORKSHIRE SWITCHGEAR
& ENGINEERING CO. LTD. **LEEDS & LONDON**

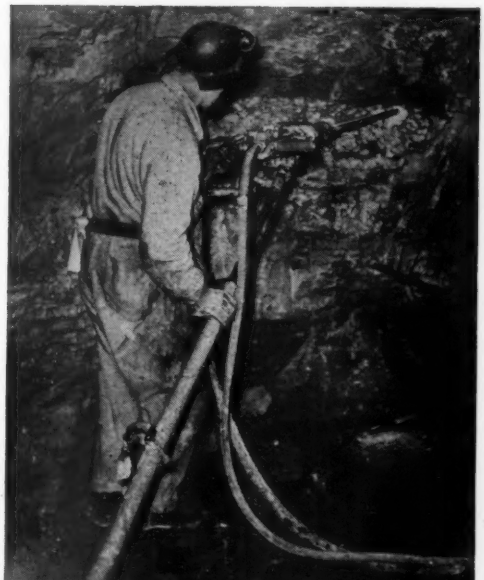
ASSOCIATED WITH ELECTRO MECHANICAL MANFG. CO. LTD. SCARBOROUGH

LONDON: Published by TOTHILL PRESS LIMITED, Proprietors of WATER POWER, at 33 Tothill Street, Westminster, S.W.1, and Printed by W. & H. SMITH LTD., Evesham, Worcestershire. *July, 1952.*

The World's First
DUSTFREE
Dry Rock Drill

To achieve a dustless dry rock drill has been the quest, the dream, of rock drill designers since the 'nineties. There could be no greater contribution to the conquest of silicosis, pneumokoniosis and other diseases caused by dust so long the scourge of the miner, and mining equipment manufacturers throughout the world have devoted their energies and resources to this problem, attempting many different solutions.

The development of an inherently *dustfree* drill for dry rock has long been a special Holman concern. Since 1945 Holman effort has been redoubled and experiments have been concentrated on the principle of dust extraction through the drill itself. Six years of intensive work were eventually rewarded with complete success—the Holman DRYDUCTOR, the first practical and effective dustfree dry rock drilling equipment, was announced to the world in December, 1950. Subsequent experience has fully justified the efforts and the original claims of the designers, and has shown that the DRYDUCTOR is indeed a complete answer to the dust problem created by drilling dry rock. The Holman DRYDUCTOR patents are undoubtedly destined to play an immensely significant role in the battle against dust diseases in mines, collieries, tunnels, quarries—wherever dry rock is drilled.

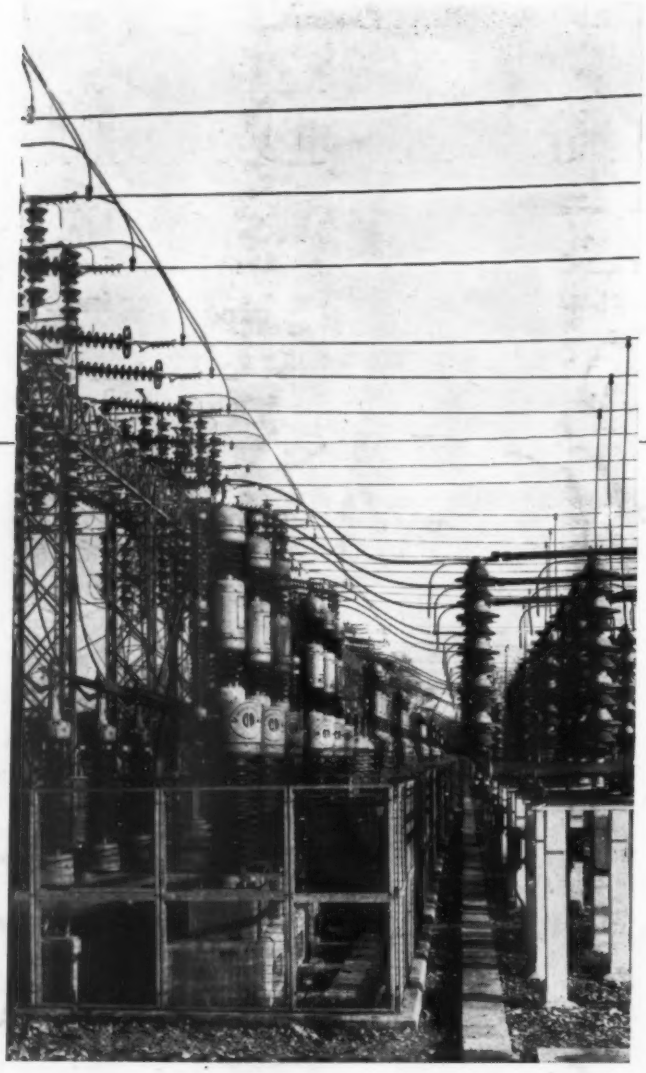


IN OPERATION IN CANADA : Holman DRYDUCTOR mounted on Airleg drilling dry rock. The photograph shows the two pipelines, one providing compressed air, the other leading the dust safely away from the operator.

The DRYDUCTOR extracts the *dry* dust as it is made, passes it through the rock drill and draws it away from the face by pipeline to a position far removed from the drills and their operators. It operates efficiently with usual methods of conserving or disposing of dust. It may be handled or used on any form of mounting, including the well-known Holman Airleg. It will drill at any angle.

BROS. LTD.
Holman
CAMBORNE . ENGLAND

TELEPHONE: CAMBORNE 2275 (9 lines) TELEGRAMS: AIRDRILL, CAMBORNE
SUBSIDIARY COMPANIES, BRANCHES AND AGENCIES THROUGHOUT THE WORLD.



One of the range

The 132 kV 2,500 MVA
two interrupter circuit-breaker
is one of the range
of 'ENGLISH ELECTRIC'
high voltage air-blast breakers
using common interrupters
and other standard parts.
The illustration shows the
Beddington sub-station of the
British Electricity Authority
where these are installed.

'ENGLISH ELECTRIC'

air-blast switchgear

THE ENGLISH ELECTRIC COMPANY LIMITED, QUEENS HOUSE, KINGSWAY, LONDON, W.C.2

Switchgear Department, Stafford

WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL · ACCRINGTON

SH.3